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Please direct correspondence to:

Kenneth A. Hashagen, Jr., Editor
California Fish and Game
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CALIFORNIA INLAND ANGLING TRENDS FOR 1971 THROUGH 1974 [1]

KRISHAN LAL
Inland Fisheries Branch
Sacramento, California 95814

This is the eleventh report on California inland sport fish catch estimates based on angler response to postal card questionnaires. Each year from 1971 through 1974, between 0.55–0.59% of the resident license buyers were mailed a questionnaire. Of these, 30–41% responded, providing a systematic sample of 0.17–0.24%. About 2,189,000 anglers, or nearly 11% of all Californians, purchased a sport fishing license in 1974. Estimated annual catch and effort by successful anglers was determined for trout, catfish, panfish, black bass, striped bass, sturgeon, and frogs. License sales, fishing pressure, and the catch estimates for black bass, striped bass, and frogs reached an all time high in 1974. Median catch per angler day was highest for frogs and lowest for sturgeon.

INTRODUCTION

Periodic angling surveys have been conducted since 1936 to determine trends in California's inland sport fish catch and effort. This is the eleventh report in the series and covers four annual surveys for the years 1971–74. Previous surveys were described by Curtis (1940), Calhoun (1950, 1951, 1953), Skinner (1955), Ryan (1959), Seeley, Tharratt, and Johnson (1963), McKechnie (1966), Emig (1971), and Pelzman (1973).

The basic format of the postal card questionnaire described by Calhoun (1950) has not been materially altered over the years to insure continuity with past surveys. Ryan (1959) grouped closely related species which are difficult for many anglers to distinguish, while others added one or more new species or questions. Although these changes helped reduce angler confusion, very little was done to improve data analysis. Emig (1971) corrected discrepancies in the 1964 survey because subjective interpretation of the terminology had resulted in wrong categorization of angler responses. Therefore, to prevent such errors in the future, I have defined the terminology, and described the logic used to classify angler responses.

The sources of sampling error and factors compensating for them were described by Calhoun (1950). Factors presumably causing exaggerated estimates were discussed by Seeley, Tharratt, and Johnson (1963). The influence of such factors on the survey is largely unknown; therefore, we cannot regard the estimates as accurate accounts of total annual catch or number of days spent angling. However, if we assume that their effect on each survey is of the same magnitude, then these estimates are useful indicators of trends in sport fishing.

California's sport fishing effort maintained an upward trend throughout the 1960's and then leveled off in the early 1970's. However, a record 2.19 million licenses were sold in 1974, and the estimated catch for black bass, striped bass, and frogs reached new highs.

METHODS

The name and address of every 25th resident sport fish license buyer in the

[1] Accepted for publication January 1977

State was recorded for the years 1971 through 1974. From these, a random sample of the sport fish anglers was drawn annually. The sample size ranged from 0.55 to 0.59% of the total number of licenses sold each year.

Each licensee included in the sample was mailed a printed postal card questionnaire (Figure 1). The 1971 questionnaire was similar to that used in two previous surveys for 1969 and 1970. The 1972 and 1973 questionnaires were identical; both were quite similar to the 1971 questionnaire except for adding American shad and frogs and separating striped bass caught in the ocean from fresh water. The 1974 questionnaire was further expanded to include the questions: "Did you go fishing or frogging in 1974?" and "Did you fish for black bass (freshwater) in 1974?"

Certain closely related species which are difficult to distinguish by most anglers were grouped on the cards to reduce confusion. The "trout" category included steelhead (*Salmo gairdneri gairdneri*) under 0.45 kg (1 lb) and kokanee salmon (*Oncorhynchus nerka*); "black bass" included largemouth bass (*Micropterus salmoides*), smallmouth bass (*M. dolomieui*), redeye bass (*M. coosae*), and spotted bass (*M. punctulatus*); "catfish" included all catfish and bullheads (*Ictalurus* spp); "panfish" included sunfish (*Lepomis* spp), crappie (*Pomoxis* spp), and various other "perch-like" fishes. American shad (*Alosa sapidissima*), steelhead larger than 0.45 kg (1 lb), striped bass (*Morone saxatilis*), sturgeon (*Acipenser* spp), and frogs (*Rana catesbeiana*) are not likely to be confused with any of the listed species.

Possible errors in completing the questionnaire were described by McKechnie (1966). In addition, I found that some anglers wrote remarks instead of the information requested, while others, apparently confused by the questionnaire, gave contradictory information. I subjectively reconciled these errors while editing the cards for key punching.

Criteria used to classify angler responses into different categories were identified for electronic data processing purposes (Figure 2). The following definitions explain the terminology used in the survey:

1. QUESTIONNAIRES MAILED: Number based on postal meter count less cards returned undelivered for various reasons.
2. UNUSABLE RETURNS: Cards belonging to any of the following groups:
   a. Blank or illegible returns;
   b. Anglers who reported fishing in waters outside California; and
   c. Licensees who fished only for abalone, clams, or scallops.
3. USABLE RETURNS: Total questionnaires returned less unusable cards. This number includes respondents who did not fish, those who were unsuccessful, and the successful respondents.
4. RESPONDENTS WHO DID NOT FISH: Anglers who did not go fishing during that year.
5. UNSUCCESSFUL RESPONDENTS: Anglers who listed only days fished for one or more species but caught no fish of any kind. However, the same angler, if successful for one species and unsuccessful for other species, was included in the category for successful anglers but was treated as an unsuccessful angler for the species for which he was unsuccessful.
6. RESPONDENTS WHO FISHED FOR TROUT: Anglers who answered yes to the question: "Did you fish for trout in _____?" This included both successful and unsuccessful trout anglers.

Will You Help Improve Fishing in California?

In order to find out whether our efforts to provide better fishing are bringing results we need to know what fish are caught each year in California. No one can tell us this as well as the fisherman.

We are therefore asking a certain number of California anglers to tell us what they catch. You have been chosen to take part in this test. Will you help? All we ask you to do is:

PLEASE WRITE ON THE RETURN CARD your best estimate of the number of each kind of fish you caught last year and the counties where you caught them. Also please give us your best estimates in answer to questions about number of days fished.

IF YOU CAUGHT NO FISH OF ANY KIND, PLEASE SAY SO.

You do not need to sign the card; this is not a personal checkup. But please do send us the record of your catch, and thus do your bit for better fishing. No postage stamp is necessary.

CALIFORNIA DEPARTMENT OF FISH AND GAME

26481-800 10-74 13,500 ⓓ OBP

PLEASE HELP TO IMPROVE FISHING BY FILLING OUT AND MAILING THIS CARD

Did you go fishing or frogging in 1974? . . . . . No ☐ Yes ☐
Did you catch any fish or frogs in 1974? . . . . . No ☐ Yes ☐
Did you fish for trout in 1974? . . . . . No ☐ Yes ☐
Did you fish for black bass (fresh water) in 1974? . . . . No ☐ Yes ☐
How many days did you go fishing in 1974? (Please give your best estimate) . _____

Please list below the number of each kind of fish you caught in each county, and the total number of days you fished for each kind.

KIND	NUMBER OF FISH	COUNTY OF CATCH	NUMBER OF FISH	COUNTY OF CATCH	NUMBER OF FISH	COUNTY OF CATCH	TOTAL DAYS FISHING FOR EACH KIND
STRIPED BASS (FROM SACRAMENTO-SAN JOAQUIN RIVER SYSTEM BAYS, AND OCEAN)							
STRIPED BASS (FROM LAKES, RESERVOIRS, COLORADO RIVER, AND CANALS)							
STURGEON							
AMERICAN SHAD							
ALL TROUT (INCLUDING STEELHEAD UNDER 1 POUND AND KOKANEE)							
STEELHEAD (1 POUND AND OVER)							
SALMON							
BLACK BASS (FRESH WATER)							
FROGS							
CATFISH							
FRESHWATER PANFISH (BLUEGILL, CRAPPIE, ETC.)							
OCEAN FISH (OTHER THAN STRIPED BASS)							

FIGURE 1. Postal card questionnaire used in 1974

7. RESPONDENTS WHO FISHED FOR BLACK BASS: Anglers who answered yes to the question: "Did you fish for black bass (freshwater) in 1974?" This question was on the 1974 questionnaire only and included both successful and unsuccessful bass anglers.

8. TOTAL DAYS FISHED: Number of days fished in a year in reply to the question: "How many days did you go fishing in _____?" It includes days listed by all successful and unsuccessful anglers and is not to be confused with the number of days fished for individual species. The latter are used in species tables for individual species.
9. SUCCESSFUL RESPONDENTS: Anglers who caught fish of any kind including ocean fish and also reported total days fished during that year. They may or may not have indicated days fished separately for each species.
10. USABLE RETURNS FOR SPECIES TABLES: As in previous surveys, only those successful anglers who reported both numbers of fish caught and days fished for that species are included in the species table.

The number of usable cards on which the results of the four surveys are based ranged from 0.17 to 0.24% of the total sport fishing licenses sold each year. All estimates furnished in the species tables are based primarily on information from successful anglers who listed the number of fish caught and days fished for that species. Thus, those anglers who failed to mention days fished separately for one or more species have been excluded from the estimates, and this has resulted in a partial reduction of the total estimated catch for all species in all surveys. In the four surveys for the years 1971–74, such anglers constituted 12–15% of all license buyers and averaged 15–36% of the total successful anglers for individual species.

For the first time in these surveys, I have reported the median annual catch per angler day for each species, based on its median annual catch and median annual days fished. This is considered a more realistic measure of the anglers daily catch than the mean catch per angler day. Also, data on unsuccessful anglers have been presented in this report for the first time. Their percentages have been determined after taking into consideration both categories of successful anglers, those who did, and those who did not list days fished.

Total angling pressure in California for the period 1935–48 was based on total fishing licenses sold and mean days fished (Calhoun 1950). These estimates are higher because the total licenses sold includes both respondents who did not fish and some unusable returns. Therefore, for computing angling pressure from 1953 onwards, I used the projected total of all successful and unsuccessful anglers instead of the total licenses sold.

RESULTS AND DISCUSSION

The results of four annual angling surveys for the years 1971 through 1974 are presented in a form similar to that of previous surveys to preserve continuity. Characteristics of all four surveys show that each year from 6.5 to 8.0% of the license buyers did not fish (Table 1). In addition, 10 to 14% of the anglers were unsuccessful. Successful anglers averaged 80% of all license buyers. Projections of angling pressure in California were updated for all surveys covering the period 1953–74 (Table 2).

Successful anglers' responses to seven of the eleven species listed on the questionnaire are summarized for each year (Tables 3 through 6). The results for salmon, steelhead, American shad, and ocean fish are not included in this report. Statewide estimates of the number of successful anglers and their catch

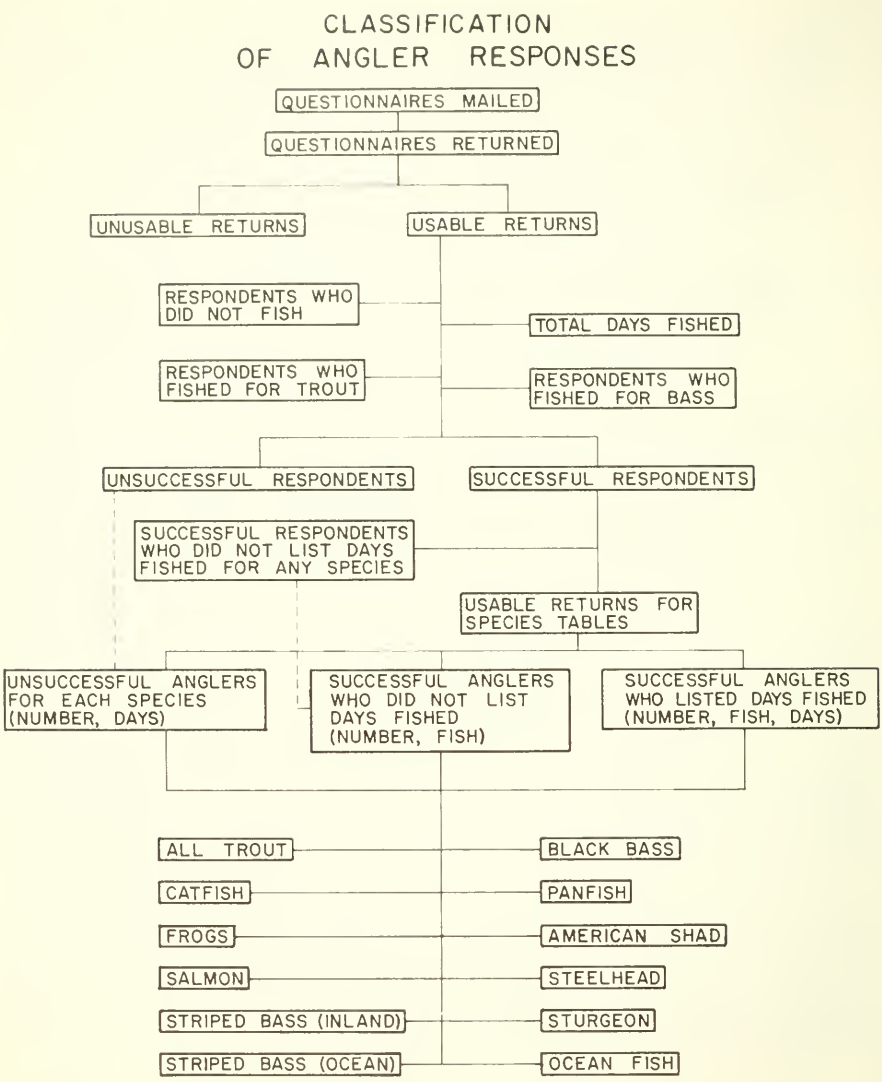

FIGURE 2. Classification of angler responses.

are given in chronological order for each of the seven species (Tables 7 through 13). Total licenses sold, fishing pressure, and catch estimates for these species are graphically presented to indicate trends (Figure 3).

The number of unsuccessful anglers for various species are reported for the years 1971–74 (Table 14). Approximately 17–33% of the anglers who fished for anadromous species (sturgeon and striped bass) were unsuccessful compared with 3–8% for freshwater species (trout, black bass, catfish, and panfish). The percentage of unsuccessful anglers was highest for sturgeon and lowest for panfish.

TABLE 1. Characteristics of the Surveys

Item	1971		1972		1973		1974	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
a. Resident sport fishing licenses sold	2,064,033		2,001,675		2,145,499		2,189,039	
b. Questionnaires mailed	11,301	0.55 (of a)	11,869	0.59	12,673	0.59	12,699	0.58
c. Questionnaires returned	3,451	30.54 (of b)	4,442	37.43	4,609	36.37	5,219	41.10
d. Usable returns	3,433	99.48 (of c)	4,395	98.94	4,574	99.24	5,180	99.25
e. Respondents who did not fish	242	7.05 (of d)	323	7.35	299	6.54	414	7.99
f. Successful respondents	2,721	79.26 (of d)	3,527	80.25	3,689	80.65	4,240	81.85
g. Unsuccessful respondents	470	13.69 (of d)	545	12.40	586	12.81	526	10.15
h. Projection factor *	601.23	–	455.44	–	469.06	–	422.59	–
i. Usable returns for species tables	2,299	66.97 (of d)	3,010	68.49	3,142	68.69	3,495	67.47
j. Mean days fished	17.27	–	19.19	–	18.02	–	20.51	–
k. Number of respondents who fished for trout	2,273	66.21 (of d)	2,874	65.39	3,021	66.05	3,446	66.53
l. Number of respondents who fished for black bass	520	15.15 (of d)	638	14.52	580	12.68	1,385	26.74

* Total angling license sales ÷ usable returns.

TABLE 2. Angling Pressure in California 1935–74

Year	Total license sales	Anglers who fished	Mean days	Total fishing days
1935	223,098	No data	No data	3,120,000
1938	346,661	"	"	4,850,000
1941	453,159	"	14.2	6,440,000
1942	433,431	"	14.3	6,180,000
1943	445,416	"	12.9	5,750,000
1946	766,753	"	13.5	10,350,000
1948	960,027	"	15.4	14,700,000
1953 [2]	1,187,367	1,136,442	14	15,910,000
1954	1,240,043	1,240,044 [3]	15	18,601,000
1956	1,380,787	1,327,049	14	18,579,000
1957	1,433,630	1,371,390	15	20,571,000
1959	1,465,440	1,406,087	16	22,497,000
1960	1,475,691	1,416,506	18	25,497,000
1964	1,585,615	1,523,265 [4]	11	16,756,000
1969	1,935,593	1,846,512	17	31,391,000
1970	2,092,355	1,964,280	18.2	35,750,000
1971	2,064,033	1,918,525	17.3	33,133,000
1972	2,001,675	1,854,552	19.2	35,589,000
1973	2,145,499	2,005,232	18.0	36,134,000
1974	2,189,039	2,014,064	20.5	41,288,000

[1] Estimates for 1935–48 based on total license sales (Calhoun 1950)
[2] Estimates for 1953–74 based on anglers who fished
[3] Incorrect projection factor (Ryan 1959)
[4] Corrected projection factor (Emig 1971)

The general trend of the four surveys covered in this report showed a 15% increase in fishing pressure since 1970 (Table 2). Estimates of the 1974 catch for black bass, striped bass, and frogs were the highest in the 39-year period covered by the surveys (Table 6). Also, in that year, 2.19 million license buyers and 20.5 mean days fished were highest on record.

Trout

Trout were the prime target for 45% of California anglers. The estimated annual catch of 12 million trout in 1936 had doubled by 1954 and more than tripled by 1969 (Table 7). Thereafter, it stabilized at about 37 million fish. Whereas these estimates of total annual catch appear exaggerated, nevertheless the number of trout caught in 1971 and 1973 very well exceeds the combined total of all warmwater fishes (black bass, catfish, and panfish). On the other hand, the mean annual catch of trout since 1936 declined drastically from 80 to 40 fish per successful angler.

Trout anglers numbered about one million in 1969, 1970, 1973, and 1974, which represents a sevenfold increase over 1936 (Table 7). The number of unsuccessful trout anglers ranged between 6–8% during 1971–74 (Table 14).

Catfish

The number of catfish anglers has exceeded panfish anglers since 1972, and they are now second in numbers to trout anglers. Successful catfish anglers comprised 15–18% of all licensees, and their ratio to trout anglers was 1:3 (Table 8). The catfish catch exceeded 10 million fish in 1960 and registered an all time

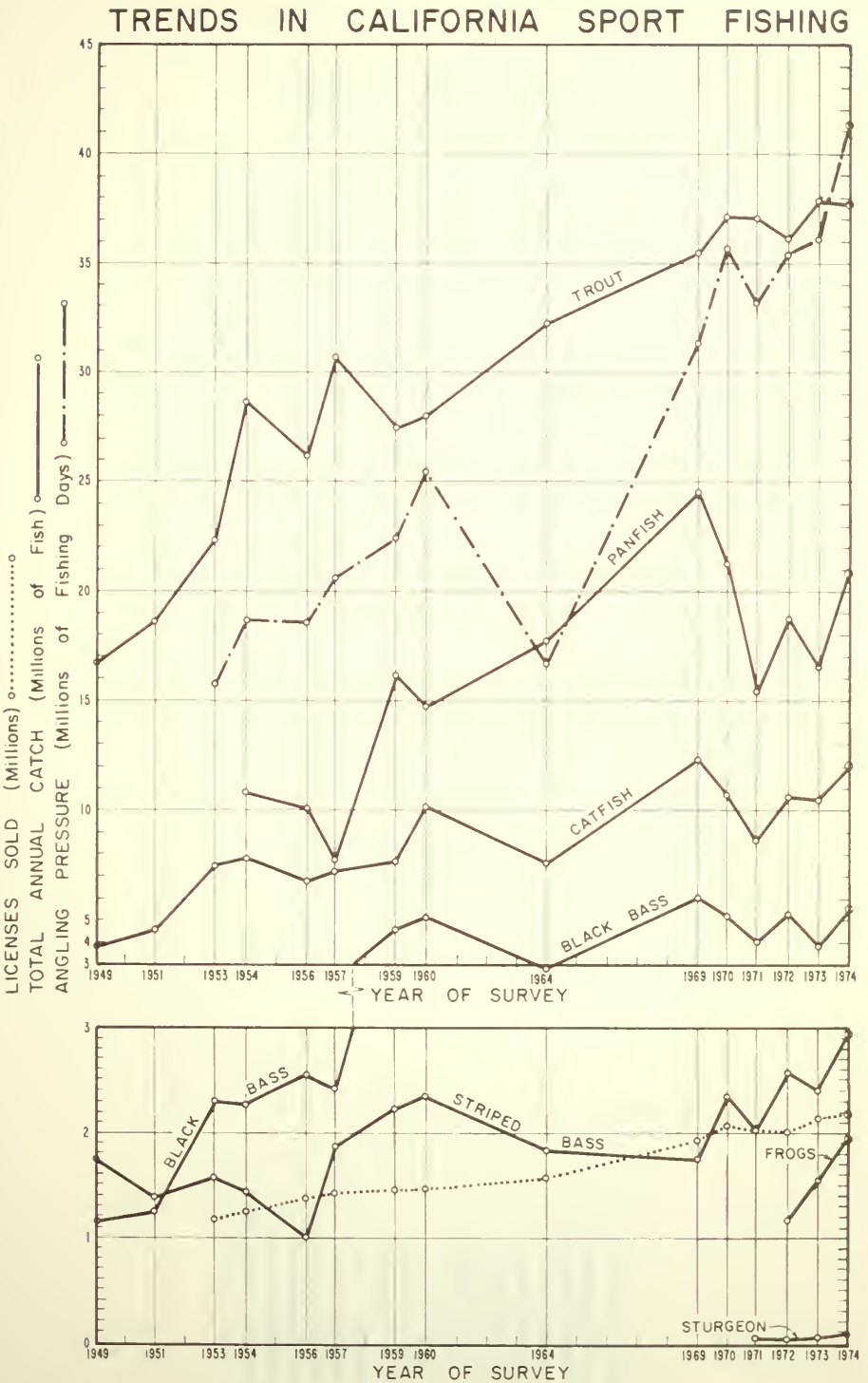

FIGURE 3. Trends in California sport fishing, 1949–1974

TABLE 3. Summary of Successful Anglers' Responses to the 1971 Statewide Angling Survey

Item	*Trout*	*Catfish*	*Black bass*	*Panfish*	*Striped bass*	*Sturgeon*
Postal card reports	1,551	518	374	575	281	30
Successful anglers	933,000	311,000	225,000	346,000	169,000	18,000
Standard error	26,000	32,000	33,000	32,000	34,000	36,000
Percentage of all licenses	45.2	15.1	10.9	16.7	8.2	0.9
Mean annual catch	39.7	27.9	18.2	44.9	12.0	3.5
Standard error	2.4	2.3	1.4	3.4	1.2	1.2
Median annual catch	20.5	11.0	10.2	20.7	5.9	1.8
Total annual catch	37,006,000	8,690,000	4,097,000	15,530,000	2,025,000	63,000
Standard error	2,220,000	715,000	308,000	1,171,000	197,000	22,000
Mean annual days	12.2	11.4	9.2	8.8	12.4	14.0
Standard error	0.5	1.3	0.6	0.6	1.2	4.5
Median annual days	7.3	5.0	5.8	4.7	5.5	4.5
Total annual days	11,393,000	3,563,000	2,071,000	3,052,000	2,088,000	253,000
Standard error	433,000	400,000	140,000	209,000	198,000	81,000
Percentage of total days	47.7	14.9	8.7	12.8	8.7	1.0
Mean catch per angler day	3.2	2.4	2.0	5.1	1.0	0.3
Median catch per angler day	2.8	2.2	1.8	4.4	1.1	0.4

TABLE 4. Summary of Successful Anglers' Responses to the 1972 Statewide Angling Survey

Item	*Trout*	*Catfish*	*Black bass*	*Panfish*	*Striped bass*	*Sturgeon*	*Frogs*
Postal card reports	1,993	764	470	713	547	63	107
Successful anglers	908,000	348,000	214,000	325,000	249,000	29,000	49,000
Standard error	22,000	27,000	29,000	28,000	–	30,000	30,000
Percentage of all licenses	45.3	17.4	10.7	16.2	12.4	1.4	2.4
Mean annual catch	39.8	30.8	24.1	58.2	10.4	1.9	24.4
Standard error	1.4	2.2	2.7	4.4	–	0.2	2.7
Median annual catch	20.5	12.8	9.8	23.6	5.8	1.9	18.5
Total annual catch	36,114,000	10,719,000	5,160,000	18,888,000	2,590,000	56,000	1,191,000
Standard error	1,271,000	781,000	587,000	1,427,000	–	6,000	133,000
Mean annual days	12.1	10.6	12.9	10.2	9.0	7.3	4.1
Standard error	0.3	0.6	1.1	0.6	–	1.2	0.5
Median annual days	7.8	5.8	5.7	5.4	5.5	4.7	2.9
Total annual days	10,975,000	3,696,000	2,769,000	3,311,000	2,253,000	208,000	201,000
Standard error	300,000	204,000	234,000	191,000	–	34,000	25,000
Percentage of total days	43.5	14.7	11.0	13.1	8.9	0.8	0.8
Mean catch per angler day	3.3	2.9	1.9	5.7	1.1	0.3	5.9
Median catch per angler day	2.6	2.2	1.7	4.4	1.1	0.4	6.4

TABLE 5. Summary of Successful Anglers' Responses to the 1973 Statewide Angling Survey

Item	*Trout*	*Catfish*	*Black bass*	*Panfish*	*Striped bass*	*Sturgeon*	*Frogs*
Postal card reports	2,061	777	425	709	550	51	102
Successful anglers	967,000	364,000	199,000	333,000	258,000	24,000	48,000
Standard error	24,000	29,000	30,000	29,000	–	32,000	32,000
Percentage of all licenses	45.1	17.0	9.3	15.5	12.0	1.1	2.2
Mean annual catch	39.2	29.0	20.0	49.7	9.4	2.8	31.9
Standard error	2.0	1.9	2.1	9.4	–	0.6	4.0
Median annual catch	20.2	10.9	8.5	16.9	4.8	1.9	19.5
Total annual catch	37,940,000	10,562,000	3,983,000	16,527,000	2,431,000	67,000	1,524,000
Standard error	1,888,000	709,000	423,000	3,111,000	–	15,000	194,000
Mean annual days	12.3	11.5	10.6	9.8	9.8	9.8	4.4
Standard error	0.5	1.2	0.8	1.0	0.8	1.5	0.5
Median annual days	3.6	5.1	5.6	4.5	5.0	4.8	2.9
Total annual days	11,817,000	4,190,000	2,123,000	3,268,000	2,529,000	235,000	210,000
Standard error	465,000	443,000	161,000	332,000	–	36,000	25,000
Percentage of total days	44.6	15.8	8.0	12.3	9.5	0.9	0.8
Mean catch per angler day	3.2	2.5	1.9	5.1	1.0	0.3	7.3
Median catch per angler day	2.7	2.1	1.5	3.8	1.0	0.4	6.7

TABLE 6. Summary of Successful Anglers' Responses to the 1974 Statewide Angling Survey

Item	*Trout*	*Catfish*	*Black bass*	*Panfish*	*Striped bass*	*Sturgeon*	*Frogs*
Postal card reports	2,303	915	629	873	671	64	119
Successful anglers	973,423	386,749	265,863	368,996	283,616	27,051	50,298
Standard error	22,672	27,616	28,534	27,752	29,324	30,468	30,194
Percentage of all licenses	44.5	17.7	12.1	16.9	12.9	1.2	2.3
Mean annual catch	38.8	31.4	21.4	56.7	10.4	3.2	38.7
Standard error	1.3	2.1	1.5	4.6	1.1	0.7	5.2
Median annual catch	20.5	10.9	10.2	20.8	5.1	1.8	20.4
Total annual catch	37,799,492	12,151,512	5,692,178	20,918,235	1,949,433	87,071	1,947,691
Standard error	1,281,625	817,457	405,685	1,715,502	139,189	17,938	260,347
Mean annual days	12.9	10.6	11.4	10.5	7.3	9.8	5.5
Standard error	0.4	0.7	0.7	0.7	0.7	1.9	0.8
Median annual days	8.1	5.2	5.6	5.0	5.5	4.5	3.0
Total annual days	12,524,313	4,103,761	3,025,515	3,861,568	2,694,982	265,441	278,966
Standard error	345,684	262,476	181,654	254,997	111,013	50,865	42,139
Percentage of total days	36.6	12.0	8.8	11.3	7.9	0.8	0.8
Mean catch per angler day	3.0	3.0	1.9	5.4	1.4	0.3	7.0
Median catch per angler day	2.5	2.1	1.8	4.2	0.9	0.4	6.8

TABLE 7. Trends in California Trout Angling

Year	Total catch	Successful anglers: Number	Successful anglers: Percentage of angling licensees	Annual catch per successful angler: Mean	Annual catch per successful angler: Median
1936	12,000,000	149,000	50	80	50
1937	11,900,000	151,000	48	78	50
1938	12,900,000	160,000	46	79	50
1939	12,800,000	179,000	49	71	37
1941	15,700,000	238,000	53	66	40
1942	16,400,000	234,000	54	70	42
1943	15,700,000	213,000	48	75	37
1946	17,660,000	357,000	47	49	25
1948	18,400,000	415,000	43	44	20
1949	16,700,000	431,000	43	39	–
1951	18,600,000	429,000	42	43	20
1953	22,300,000	530,000	44	42	22
1954	28,600,000	578,000	47	50	22
1956	26,200,000	640,000	46	41	21
1957	30,700,000	718,000	50	43	21
1959	27,480,000	660,000	45	41	21
1960	28,000,000	709,000	48	39	21
1964	32,296,000	788,000	50	41	21
1969	38,520,000	1,006,000	52	38	18
1970	37,058,000	1,087,000	52	34	18
1971	37,006,000	933,000	45	40	21
1972	36,114,000	908,000	45	40	21
1973	37,940,000	967,000	45	39	20
1974	37,799,000	973,000	45	39	21

high of 12 million fish in 1974. While the estimated catch quadrupled and the number of catfish anglers increased tenfold over 1936, the mean annual catch since 1948 has fluctuated between 24–37 fish per successful angler. Only 4–6% of the catfish anglers were unsuccessful during 1971–74 (Table 14).

Black Bass

The black bass catch estimates have fluctuated between 3 and 6 million fish since 1959 (Table 9). The approximate sixfold increase in its catch since the inception of the surveys is the highest for any species. The number of bass anglers increased sevenfold since 1936, but the percentage they comprise of the total licensees dropped from 11–18% during 1936–46, 11–14% in 1948–57, 14–16% in 1959–70, and 8–9% in 1971–74. The marked decline for the period 1948–57 also coincided with it lowest mean annual catch of 10–16 fish per successful angler. Of the total anglers who fished for bass during 1971–74, 7–9% were unsuccessful (Table 14).

Panfish

Panfish were second to trout in number of fish caught annually, but panfish anglers during 1971–74 comprised only about 17% compared to 45% for trout anglers. From 1954 to 1974, both the estimated panfish catch and the number of successful anglers nearly doubled (Table 10). The mean annual catch of 45–58 fish per successful angler during 1971–74 was the highest among all species. Also, for the same period, the percentage of unsuccessful anglers (3–4%) was lowest (Table 14).

TABLE 8. Trends in California Catfish Angling

Year	Total catch	Successful anglers: Number	Successful anglers: Percentage of angling licensees	Annual catch per successful angler: Mean	Annual catch per successful angler: Median
1936	2,940,000	38,000	13	78	—
1937	2,810,000	43,000	14	65	—
1938	3,480,000	48,000	14	72	—
1939	4,333,000	75,000	20	58	—
1941	6,100,000	97,000	21	63	—
1942	8,250,000	110,000	25	75	—
1943	7,060,000	101,000	23	70	—
1946	6,530,000	149,000	19	44	—
1948	5,560,000	182,000	19	31	15
1949	3,930,000	161,000	16	24	12
1951	4,710,000	171,000	17	29	12
1953	7,500,000	225,000	19	33	15
1954	7,990,000	220,000	18	37	13
1956	6,970,000	217,000	16	32	10
1957	7,370,000	259,000	18	28	13
1959	7,674,000	232,000	16	32	10
1960	10,100,000	275,000	19	37	15
1964	7,684,000	284,000	18	27	11
1969	12,319,000	422,000	22	29	10
1970	10,784,000	418,000	20	26	10
1971	8,690,000	311,000	15	28	11
1972	10,719,000	348,000	17	31	13
1973	10,562,000	364,000	17	29	11
1974	12,152,000	387,000	18	31	11

Striped Bass

Except for 4 years, the striped bass estimated catch from 1936 to 1969 remained between 1 and 2 million fish annually (Table 11). Since 1970, it went above 2 million fish and in 1974 was about 3 million fish, due to additional fishing in the California Aqueduct and its reservoirs. To what extent the increased catch estimates after 1971 were influenced by combining striped bass caught in the ocean and fresh water is not known. The number of successful striped bass anglers has more than tripled since 1936, and they accounted for 8–13% of all licensees during 1971–74. The mean catch since 1946 was between 8–12 fish per successful angler. About 17% of striped bass anglers were unsuccessful (Table 14).

Sturgeon

The number of anglers and the total sturgeon catch have fluctuated sharply, probably due to small sample size from the few usable responses (Table 12). It is, therefore, difficult to judge trends.

Only 1% of the California anglers fished for sturgeon. Of these about one-third (32–34%) were unsuccessful, which was the highest for all species (Table 14).

Frogs

Information on frogging was also collected first in the 1972 survey, when the estimated catch was over one million frogs. By 1974, it had doubled (Table 13). The mean annual catch of 24 frogs per successful angler in 1972 jumped to 39 frogs in 1974. Only about 5–7% of the froggers were unsuccessful (Table 14).

TABLE 9. Trends in California Black Bass Angling

Year	Total catch	Successful anglers: Number	Successful anglers: Percentage of angling licensees	Annual catch per successful angler: Mean	Annual catch per successful angler: Median
1936	930,000	34,000	11	27	–
1937	849,000	33,000	11	26	–
1938	1,190,000	46,000	13	26	–
1939	1,340,000	67,000	18	20	–
1941	1,530,000	75,000	17	20	–
1942	1,340,000	66,000	15	20	–
1943	1,570,000	79,000	18	20	–
1946	1,700,000	104,000	14	16	–
1948	1,890,000	128,000	13	15	6
1949	1,160,000	116,000	12	10	5
1951	1,280,000	108,000	11	12	6
1953	2,300,000	161,000	14	14	9
1954	2,300,000	154,000	12	15	8
1956	2,550,000	164,000	12	16	9
1957	2,440,000	179,000	12	14	8
1959	4,493,000	218,000	15	20	9
1960	5,150,000	235,000	16	22	9
1964	2,992,000	217,000	14	14	8
1969	6,067,000	306,000	16	20	9
1970	5,327,000	313,000	15	17	8
1971	4,097,000	225,000	11	18	10
1972	5,160,000	214,000	11	24	10
1973	3,983,000	199,000	9	20	8
1974	5,692,000	266,000	12	21	10

TABLE 10. Trends in California Panfish Angling

Year	Total catch	Successful anglers: Number	Successful anglers: Percentage of angling licensees	Annual catch per successful angler: Mean	Annual catch per successful angler: Median
1954	10,970,000	205,000	17	53	26
1956	10,020,000	225,000	16	44	18
1957	7,680,000	244,000	17	31	17
1959	16,114,000	281,000	19	56	22
1960	14,740,000	296,000	20	50	22
1964	17,793,000	326,000	21	55	20
1969	24,668,000	463,000	24	53	22
1970	21,257,000	486,000	23	44	20
1971	15,530,000	346,000	17	45	21
1972	18,888,000	325,000	16	58	24
1973	16,527,000	333,000	16	50	17
1974	20,918,000	369,000	17	57	21

Species Rankings

For the year 1974, all seven species covered in this report were ranked by several factors. These include the percent of total licensees who fished for each species, percent of successful anglers for each species, ratio of successful anglers to unsuccessful anglers, mean annual catch, mean annual days fished, mean and median catch per angler day (Table 15). The ranking of species on six different criteria puts into perspective their relative importance as measured by angler response.

TABLE 11. Trends in California Striped Bass Angling

Year	Total catch	Successful anglers: Number	Successful anglers: Percentage of angling licensees	Annual catch per successful angler: Mean	Annual catch per successful angler: Median
1936	2,110,000	84,000	28	25	
1937	2,040,000	82,000	26	25	
1938	1,940,000	93,000	27	21	
1939	1,880,000	89,000	24	21	12
1941	1,940,000	107,000	23	18	10
1942	1,680,000	88,000	20	19	
1943	1,680,000	75,000	17	22	9
1946	1,380,000	113,000	15	12	6
1948	1,650,000	161,000	17	10	5
1949	1,750,000	165,000	17	11	5
1951	1,490,000	144,000	14	10	5
1953	1,590,000	166,000	14	10	6
1954	1,440,000	158,000	13	9	5
1956	1,000,000	127,000	9	8	5
1957	1,890,000	230,000	16	8	5
1959	2,260,000	224,000	15	10	5
1960	2,770,000	231,000	16	12	5
1964	1,838,000	202,000	13	9	4
1969	1,747,000	214,000	11	8	4
1970	2,380,000	236,000	11	10	5
1971	2,025,000	169,000	8	12	6
1972[1]	2,590,000	249,000	12	10	6
1973[1]	2,431,000	258,000	12	9	5
1974[1]	2,949,000	284,000	13	10	5

[1] Figures combined for striped bass caught in the ocean and fresh water.

TABLE 12. Trends in California Sturgeon Angling

Year	Total catch	Successful anglers: Number	Successful anglers: Percentage of angling licensees	Annual catch per successful angler: Mean	Annual catch per successful angler: Median
1969	91,000	30,000	2	3	2
1970	67,000	27,000	1	3	1
1971	63,000	18,000	1	4	2
1972	56,000	29,000	1	2	2
1973	67,000	24,000	1	3	2
1974	87,000	27,000	1	3	2

TABLE 13. Trends in California Frogging

Year	Total catch	Successful anglers: Number	Successful anglers: Percentage of angling licensees	Annual catch per successful angler: Mean	Annual catch per successful angler: Median
1972	1,191,000	49,000	2	24	19
1973	1,524,000	48,000	2	32	20
1974	1,948,000	50,000	2	39	20

TABLE 14. Trends for California Unsuccessful Anglers

Species	1971		1972		1973		1974	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1. Panfish	20,000	4	18,000	4	15,000	3	17,000	3
2. Frogs	–	–	4,000	6	3,000	5	5,000	7
3. Catfish	24,000	5	25,000	5	29,000	6	23,000	4
4. Trout	93,000	8	79,000	7	83,000	7	80,000	6
5. Black bass	24,000	8	19,000	7	18,000	7	38,000	9
6. Striped bass	46,000	17	65,000	17	86,000	21	77,000	17
7. Sturgeon	13,000	32	16,000	33	17,000	34	19,000	33

TABLE 15. California Sportfish Rankings for Successful Anglers in 1974 [1]

Species rank	Percentage of total licensees	Successful anglers: Percentage	Successful anglers: Ratio to one unsuccessful angler	Mean annual catch	Mean annual days fished	Mean catch per angler day	Median catch per angler day
1	Trout 45	97	Panfish 32	Panfish 57	Trout 13	Frogs 7.0	Frogs 6.8
2	Catfish 18	96	Catfish 24	Trout, Frogs 39	Black bass, Catfish, Panfish 11	Panfish 5.4	Panfish 4.2
3	Panfish 17	94	Trout 16	Catfish 31	Striped bass, Sturgeon 10	Trout, Catfish 3.0	Trout 2.5
4	Striped bass 13	93	Frogs 13	Black bass 21	Frogs 6	Black bass 1.9	Catfish 2.1
5	Black bass 12	91	Black bass 10	Striped bass 10	–	Striped bass 1.1	Black bass 1.8
6	Frogs 2	83	Striped bass 5	Sturgeon 3	–	Sturgeon 0.3	Striped bass 0.9
7	Sturgeon 1	67	Sturgeon 2	–	–	–	Sturgeon 0.4

[1] 1974 was selected as the latest year for which data were available

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MOVEMENTS OF BANDED MOURNING DOVES NEAR TURLOCK, CALIFORNIA[1]

EDWARD CHANNING
1115 Sierra Drive
Turlock, California 95380

The Mourning Dove (*Zenaida macroura*) is abundant around Turlock at all seasons of the year, but the composition of the population varies seasonally. Present at all times is a resident breeding population that does not migrate or make any substantial movements. There is also a southward flow of transient doves in summer and fall, and a return northward flow in late winter and spring. The seasonal passage of migrants southward and northward through Turlock does not seem to draw any locally fledged doves into migration.

Changes in land use in the rural countryside around Turlock are generally adverse to the welfare of doves and there is probably a gradual decline in numbers. However, within the rapidly expanding urban sprawl fringing the city, the doves are finding optimum habitat and perhaps increased carrying capacity.

INTRODUCTION

The Turlock area in central California, where this study was conducted, lies between the San Joaquin River and the Sierra Nevada foothills in Stanislaus and Merced counties. The terrain is essentially level and is intensively developed for agriculture. Most of the land is subject to irrigation. Orchards, vineyards, alfalfa, corn, and other grains are primary crops. Limited areas are maintained in pasture. Residential developments are spreading out from the central city. My study focused largely on the area 16 km (10 miles) in radius around Turlock.

The Western Mourning Dove (*Z. m. marginella*), is a common breeding bird in the Turlock area. From 1961 to 1968, I banded nestling doves in various locations around Turlock. Additionally, I was permitted to incorporate data on nestlings banded near Turlock by personnel of the Fish and Wildlife Service and other individual banders for the years 1924 to 1971.

From 1967 to 1974, doves were trapped in stubble fields where they came to feed during two seasons of the year: (1) pre-shooting season, July and August; and (2) post-shooting season, January to April. Shooting season in California includes the month of September, and, since 1965, a late season of about 2 weeks in December. No trapping was conducted during the autumn period.

To better understand the southward fall migration of doves through the Turlock area I was permitted to cite recoveries from doves banded in the vicinity of Yakima, Washington, by the Fish and Wildlife Service and collaborators in the years 1964 to 1969. Likewise, Fish and Wildlife Service records of doves banded elsewhere and killed in the Turlock area further elucidate seasonal movements.

Additionally, this report includes some observations on dove natural history, food predilections, and effects of land use changes on dove welfare.

NESTING

Courtship flights are first seen in late January and the first eggs are laid in February. However, it is usually in March that nesting really gets underway. In other California dove nesting studies, McClure (1950) reported nesting to begin

[1] Contribution from Museum of Vertebrate Zoology, Berkeley, California 94720. Accepted for publication August 1978.

in Kern County about March 14 and Cowan (1952) gave the same date for beginning of incubation of the earliest nests in Butte County. The full swing of dove nesting is underway in April.

A successful nesting cycle of the Mourning Dove requires approximately 30 to 34 days, distributed as follows: 3 to 6 days of nest construction and egg laying, 14 days for incubation, 11 to 14 days for young to reach fledgling stage. Immediately after completion of one cycle a pair of doves will embark on another. Since the period of nesting extends from March into September, a pair potentially can bring off six broods of two young each (Keeler 1977). In 1962 a pair of doves achieved this potential in a nest situated under the protective eaves of the author's home in Turlock. Two young each were fledged April 17, May 14, June 15, July 15, August 17, and September 12, for a total of 12 young. Cowan (1952) reported a similar feat accomplished by a pair of doves nesting on Gray Lodge State Game Refuge, Butte County. Few pairs, however, achieve this level of production. Cowan found that the average pair reared 6.0 to 6.8 young per season.

Dove nesting in California generally terminates in early September. McClure (1950) recorded his last nesting near Bakersfield fledging about September 14. Cowan (1952) reported terminal dates between September 7 and 18. Most of the nesting that I observed near Turlock was terminated by early September. However, one determined pair nesting in a hanging flower basket in a patio in central Turlock fledged its final brood on November 24, 1974. Such persistence is rare and probably only occurs in an urban setting. This nest in fact produced 19 successful nestings (38 fledged young) in the period 1972 to 1976.

NESTLING BANDING

From 1961 to 1963 I banded 200 nestlings in and around the city of Turlock and in an 8-ha (20-acre) almond orchard nearby. Also, the Fish and Wildlife Service supplied records of 756 dove nestlings banded near Turlock. When these additional nestlings are included with my bandings, 1,093 young doves were banded from 1924 to 1971 within 48 km (30 miles) of Turlock (Table 1).

From 1963 to 1967 I banded 137 nestling doves in a 40-ha (100-acre) vineyard; records were kept on 123 nests observed (Table 2). Nests were located in May while the vines were being suckered. Most nests were situated in the crown of the grapevines, about 1 m (3 to 4 ft) above the ground. Nests were visited regularly (at least 3 times) and the young were banded when about 10 days old, or a few days before they would fledge. Nestlings were banded between May 22 and June 26. Although doves renested in the vineyard, I did not attempt to find nests or band young after the end of June because the dense vine growth rendered the nests difficult to locate. The average hatch of eggs in the vineyard nests was 62.0% which is close to the findings of McClure (67.1%).

Fifty-six bands were reported over a 4-year period following banding, for a 5.1% recovery (Table 3). All were recovered within the Central Valley and most within a short radius of Turlock (Figure 1). Whereas other studies have shown a strong tendency for young doves to drift southward during late summer (Hanson and Kossack 1963, Lehner 1965), my population would appear to be essentially sedentary. Fifty-four of the 56 recoveries occurred in September. One nestling was shot in November, and another was found dead in January. The fact that recoveries occurred locally for several years after banding strongly

TABLE 1. Mourning Doves Banded in the Turlock Area and Number of Recoveries. All reported recoveries were from hunting

	Number banded	*Recoveries*	*Percent recovery*
NEST BANDED			
Nestlings	1093	56	5.1
TRAP BANDED			
Summer			
Immature	831	83	10.0
Adult	126	17	13.5
Total	957	100	10.4
Winter			
Male	515	46	8.9
Female	502	29	5.8
Total	1017	75	7.4
GRAND TOTALS	3067	231	7.5

TABLE 2. Dove Nesting Record from 40 ha Vineyard 8 km NW of Turlock

	Year					
	1963	*1964*	*1965*	*1966*	*1967*	*Total*
Nests found	21	35	29	21	17	123
Eggs laid	42	66	58	42	34	242
Eggs hatched	28	50	22	27	23	150
Percent hatched	66.6	75.7	37.9	64.0	67.6	62.0
Fledglings banded	26	47	20	23	21	137

TABLE 3. Returns of 1,093 Doves Banded as Nestlings in the Turlock Area, 1924–1971.

		Year after banding			
Number banded		*1st year*	*2nd year*	*3rd year*	*4th year*
Number recovered	56*	42	8	3	3
Percent recovery	5.1	3.8	.7	.3	.3

* Recovered within degree block of banding 48
Recovered from points N of banding site (56 and 257 km) 3
Recovered from points S of banding site (up to 121 km) 5
56

supports the conclusion that birds bred in the Turlock area are year-long residents. In any event, not one bird known to have been locally fledged was recovered outside of the Valley.

SUMMER TRAP BANDING

During the month of June, oat stubble fields are prime dove feeding areas due to the presence of red maids (*Calandrinia caulescens*), a common weed whose tiny black seeds are a principal summer food of doves (Browning 1959). This plant sprouts with the oats during the late fall and matures early in spring. The seeds on the ground become available when the oats are harvested. Twenty to

Figure 1 Recoveries of 56 banded nestlings over a 4-year period following banding. Forty-eight of the recoveries came from inside the 40 km radius circle around Turlock.

thirty trap sites were then cleared of stubble and prebaited with chicken scratch. When dove use was evident, traps were set and checked each morning and evening. Traps were constructed of 2- x 1-inch gauge welded wire, with entrance funnels located at both ends and a hinged door for removal of doves (Figure 2). The pre-season trapping period extended from July 9 to August 30.

Sex is indistinguishable in recently fledged doves, but young are easily distinguished from adults by the presence of juvenile wing coverts. Summer banding seems to be differentially selective for immature birds—those locally produced and those drifting through from northern breeding areas. Birds-of-the-year constituted 86.8% of the 957 birds banded in July and August (Table 4). Each pair of breeding doves can be expected to produce 6.0 to 6.8 young per season (Cowan 1952). The age ratio at the end of the breeding year, therefore, could be no more than 75 to 77% young. The real age ratio during July and August

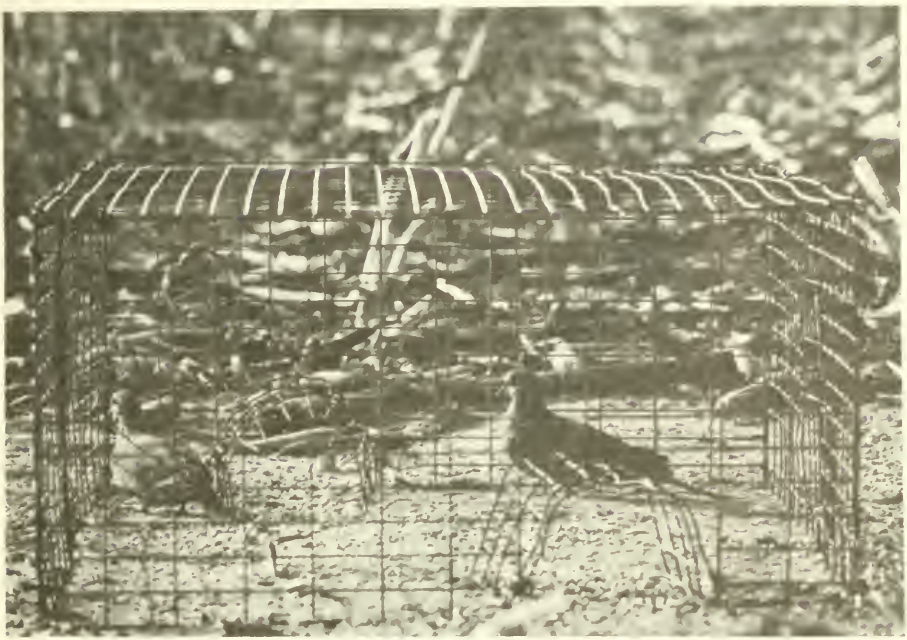

Figure 2. Dove trap used in this study, showing funnel entrances.

must be considerably less than that since all young for the season are not yet fledged, and mortality of fledglings must be higher than that for adults as suggested by the lower recovery rate of birds banded as nestlings (Table 1).

TABLE 4. Records of Summer Banding in Traps

	Birds banded				*Returns*			
Year	*Total*	*Adults*	*Immatures*	*Percent immatures*	*Total returns*	*Returns < 40 km*	*Distant returns*	*Percent returns*
1968	33	12	21	63.6	6	4	2	18.3
1969	137	24	113	82.5	23	20	3	16.8
1970	281	10	271	96.4	25	16	9	8.8
1971	249	34	215	86.3	24	22	2	9.2
1972	103	12	91	88.3	6	4	2	5.8
1973	49	12	37	75.5	2	2	0	4.1
1974	105	22	83	80.5	14	14	0	13.3
Total	957	126	831	86.8	100	82	18	10.4

The recovery percentages for summer-banded immature and adult doves during the first shooting season following banding (direct recovery) are 10 and 13.5%, respectively. Eighty-two percent of the 100 recoveries were within 40 km (25 miles) of the banding site (Figure 3), all shot in September. Six immatures and one adult were recovered in Mexico during the winter months at distances of 1,900 to 2,900 km (1,200 to 1,800 miles) south of the banding location. Of 18 recoveries at distances in excess of 40 km, 15 were south and 3 were north of the banding site. Greatest longevity was an immature banded in 1969 and recovered in 1974 near Villa Victoria, Michoacan, Mexico.

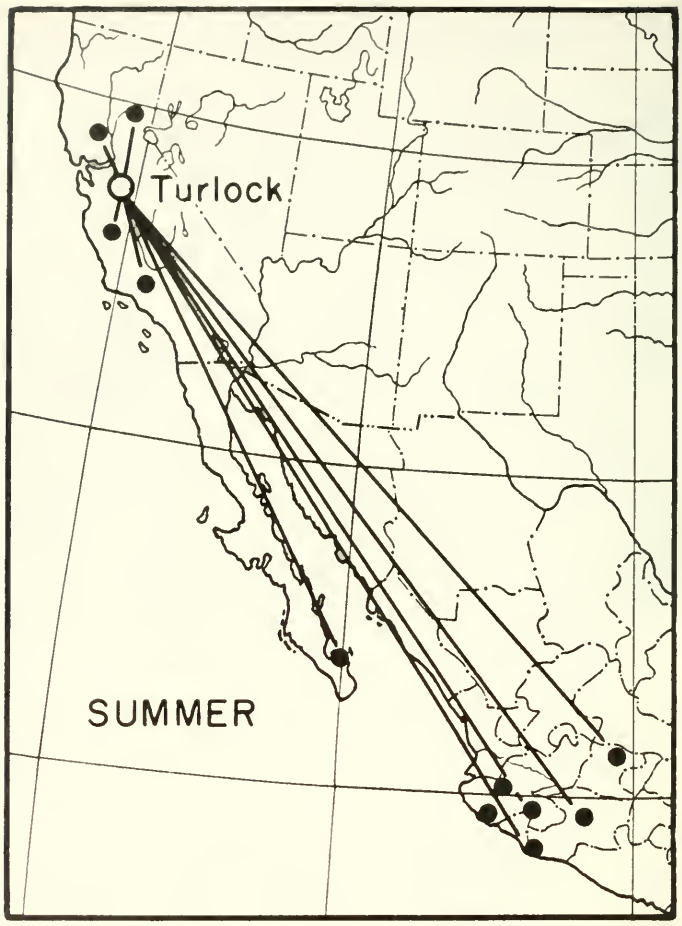

Figure 3. Recoveries of 100 summer-trapped doves, 82 of which were taken within 40 km (shown by circle) of Turlock.

From these recovery data it would appear that some birds are southward bound through the Turlock area in July and August. In point of fact, the initiation of hunting September 1, plus the early fall storms that often occur then, seem to induce substantial shifts in dove populations and the drift is generally southward.

WINTER TRAP BANDING

During the winter months doves feed primarily on corn kernels dropped to the ground during harvest. Although there are many corn fields that appear suitable for dove foraging, the birds often are found concentrated by the thousands in a few fields. My winter trapping involved first finding the fields currently in use by doves and then pre-baiting and setting traps in the same manner as during summer.

In winter the sexes of doves are discernible but age cannot be distinguished. The sex ratio of 1,017 doves banded during January, February, and early March, was almost equal—515 males to 502 females (Table 5). However, later in spring, I captured more males (166) than females (134), suggesting that perhaps a greater number of males were migrating into or through the Turlock area at that time.

TABLE 5. Records of Winter Banding in Traps

	Birds Banded			*Recoveries*					
Year	*Total*	*Males*	*Females*	*Total returns*	*Recoveries < 40 km*		*Distant recoveries*		*Percent recovery*
					M	F	M	F	
1967	71	40	31	6	3	2	1		8.5
1968	118	64	54	10	4	3	3		8.5
1969	368	187	181	34	14	13	5	2	9.2
1970	78	40	38	5	1	1	2	1	6.4
1971	128	65	63	8	4	4			6.2
1972	121	59	62	6	3		1	2	4.9
1973	66	30	36	4	2		2		6.1
1974	67	30	37	2			1	1	2.9
Total	1017	515	502	75	31	23	15	6	7.4

Of 75 recoveries of winter-banded birds, 54 were taken in subsequent hunting seasons within 40 km (25 miles) of the site of banding, and 21 were taken at more distant points (Figure 4). Whereas summer banding recoveries were mostly from points to the south of Turlock, winter taken birds were more varied in their movements—north (6), east (4), south (10), and west (1). Yet all but two of these recoveries came from the Central Valley or Sierra foothills. Three doves banded in February or March were shot near Turlock the following December. Three others were recaptured in my traps—one the following September, two a year later in March. One female was shot at Brewster, Washington, 32 months after banding, and a male was recovered near Ukiah in Mendocino County.

Although the sexes were banded in almost equal numbers, band recoveries were higher in males, particularly at distant points (35.00 to 15.00) and in years subsequent to the year of banding (22.00 to 10.00). I presume that males wander farther than females and that they live longer.

DOVES BANDED ELSEWHERE

The movements of doves in and about Turlock are further elucidated by recoveries of birds banded elsewhere (Figure 5). Twelve winter-banded birds came from points in Arizona, New Mexico, and Texas, suggesting a spring migration to California or points beyond for breeding. Thus far, there have been no recoveries in those areas of doves banded here. Eighteen summer-banded birds came from sites largely to the north and east of Turlock. One recovery of particular interest was a nestling banded in eastern Michigan and recovered here 15 months later. Presumably this bird would have been of the eastern race of Mourning Dove (*Z. m. carolinensis*) and a true vagrant rather than a migrant. But most of the summer banded doves shot near Turlock in September presumably were following normal movements from their breeding areas to wintering

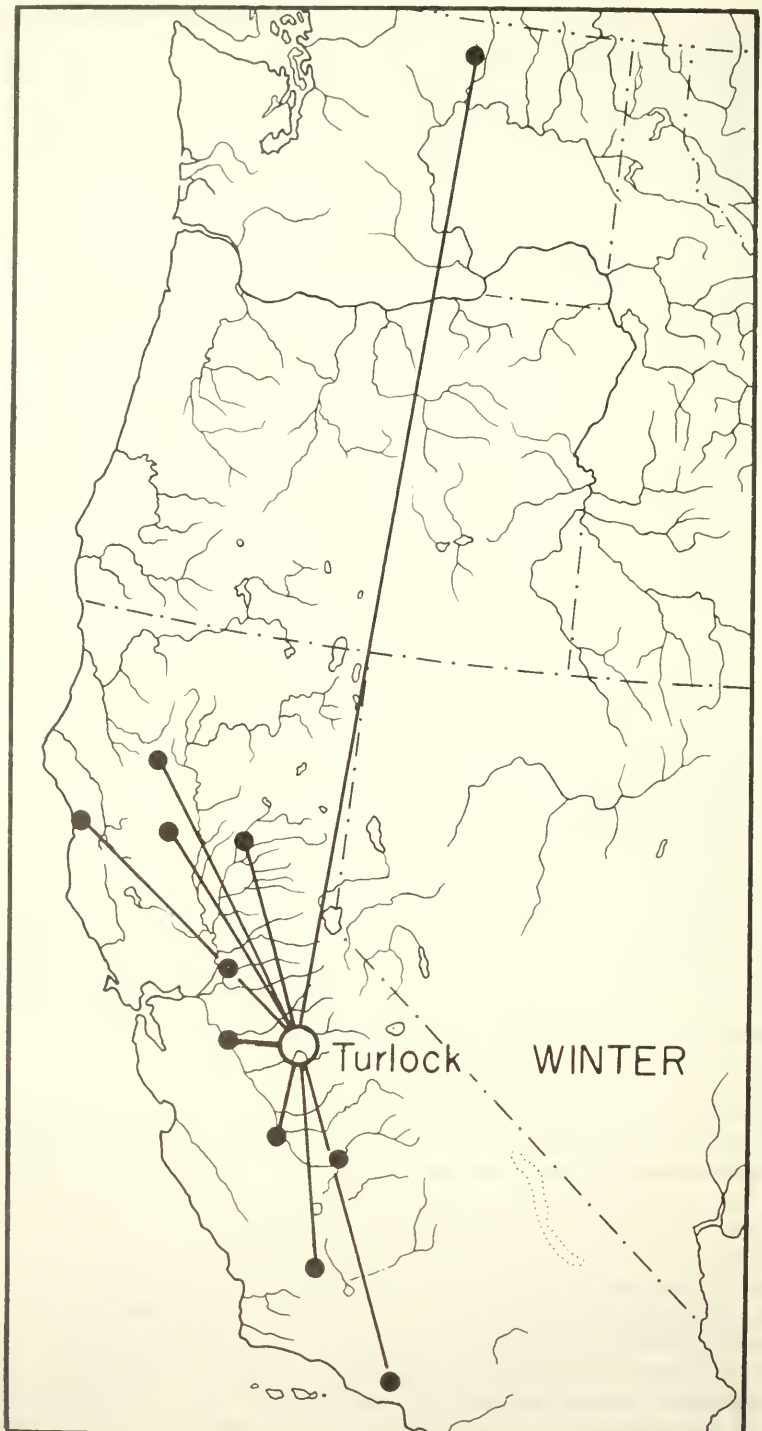

Figure 4. Recoveries of 75 winter-trapped doves, 54 of which were taken within 40 km (shown by circle) of Turlock.

grounds. As the map clearly shows, there is no well defined pattern to these fall movements, the incoming migrants originating from widely scattered localities in the western states.

Evidence of the strong southward drift of doves originating in populations north of Turlock is shown by recoveries of birds banded in summer (pre-season) in the vicinity of Yakima, Washington, in 1964, 1968, and 1969 (Figure 6). Of the 87 recoveries outside of the block in which the banding occurred (lat 46°N, long 120°W), all were generally to the south—3 in Oregon; 37 in California; 14 in the Rocky Mountain states (Nevada 4, Utah 3, Arizona 4, Colorado 2, New Mexico 1); and 33 in Mexico, mostly in the central highlands west of Mexico City. One adventuresome traveler went as far south as El Salvador.

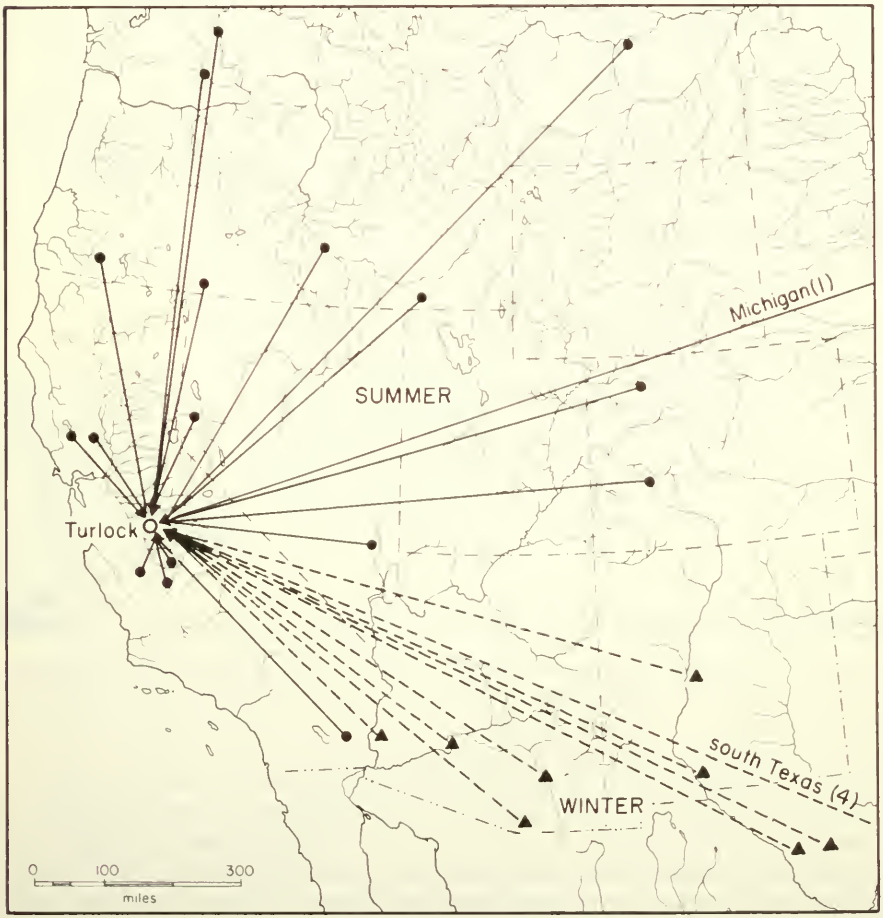

Figure 5. Banding locations of 30 doves subsequently shot near Turlock. Twelve winter-banded birds (triangles) came from banding stations southeast of Turlock. Eighteen summer-banded birds (circles) came from all points of the compass but mostly from northerly stations.

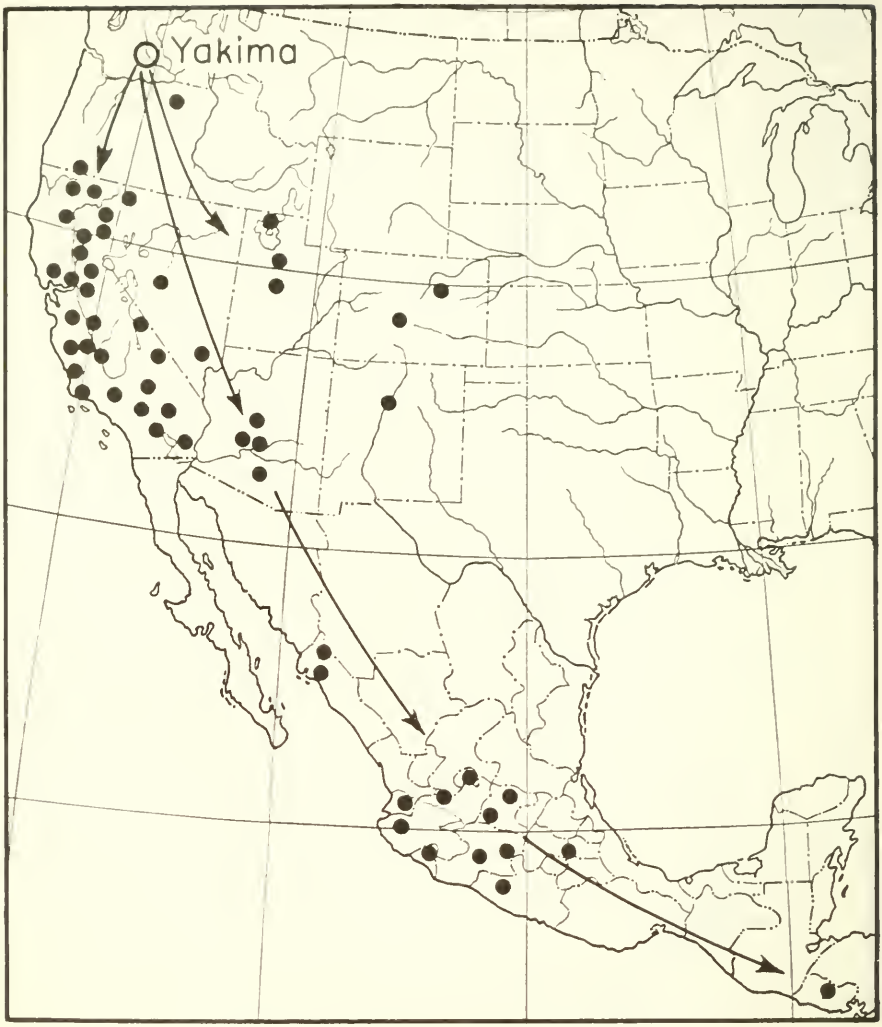

Figure 6. Points of recovery of 87 doves banded in summer near Yakima, Washington, and recovered outside of the banding locality. A strong southward drift is indicated.

CONCLUSIONS REGARDING DOVE MOVEMENTS

Considering all the data available to me, I conclude that the population of doves nesting in the Turlock area is basically resident and does not migrate. Of 56 locally bred birds banded and subsequently recovered over a 4-year period, not one had left the Central Valley and only 8 had wandered far in the Valley itself.

Among birds trapped and banded in summer, there seems to be a mixture of locally produced juveniles that will not migrate and drifting juveniles from breeding sites to the north and east that are in transit southward. A number of these

migrants end up in distant areas, as far south as central Mexico. Relatively few adults are captured in summer and I presume that the ones captured are local breeders.

The winter situation is more complex. However, my personal interpretation is as follows: the winter trapped doves include many local residents, but with a substantial mixture of birds that have come here to winter from their breeding sites in the Pacific and Rocky Mountain states, and some transient migrants that have spent the mid-winter months in Texas, New Mexico, Arizona, and probably Mexico, and are on their way back to more northerly nesting areas in March. Some of these transients will return southward through Turlock and be represented in the September hunting bag.

The seasonal intermixture of resident and migratory doves is somewhat comparable to the White-crowned Sparrows (*Zonotrichia leucophrys*) of the Pacific seaboard, first described by Blanchard (1941). A resident population of sparrows (*Z. l. nuttalli*) lives year-round along the California coast from Eureka to Santa Barbara. Each autumn an invading population of migrants (*Z. l. pugetensis*) sweeps down the coast from the breeding grounds in coastal Oregon, Washington, and Vancouver and mixes with the resident sparrows. But in spring the migrants depart, leaving the local birds to pursue their own breeding cycle. The two populations of sparrows are virtually identical morphologically, but there is a recognizable difference in the song. The two populations of doves are indistinguishable by any criteria known to me, except that one is resident and the other is migratory.

CHANGING LAND USE AFFECTING DOVES IN THE TURLOCK AREA

During the Gold Rush, Stanislaus County was largely devoted to livestock grazing, but in the 1860's increasing areas were plowed for dry grain farming. In 1868 the County produced nearly 2,500,000 bushels of wheat which made it the grain center of California. In 1871 Miller and Lux began to build the San Joaquin Canal in the southwestern part of Stanislaus County, and, with the establishment of the Turlock Irrigation District in 1887, irrigation became the new trend. Grain farming was pushed into the less productive foothills, and the rich bottomlands, once famous for wheat, were converted to orchards, vineyards, dairies, and row crops. The amount of irrigated land increased from 1,522 ha (3,757 acres) in 1901 to 69,107 ha (170,635 acres) in 1974. With irrigation has come much more intensive farming, with decreasing habitat for most wildlife, including doves. Oat stubble, which provides prime summer feeding sites, has decreased drastically; in 1976 I drove hundreds of miles around Turlock without finding a field suitable for dove trapping. Sprinkler irrigation itself is menacing to nesting doves; I found 12 out of 17 nests in an almond orchard broken up by spraying. The rural landscape around Turlock, as a home for mourning doves, is gradually deteriorating.

Evidence of recent trends in dove numbers is inconclusive. Data obtained from the mourning dove call count made by the Department of Fish and Game each year since 1966 showed an apparent decrease in numbers of cooing males from 1966 to 1975, but a sharp increase in the years 1976 to 1978 along three counting routes in the general vicinity of Turlock (Table 6). Deteriorating habitat is not reflected in this measure of abundance. However, the Department annual-

ly conducts a mail survey of hunters, and the returns from Stanislaus County suggest a falling success ratio among dove hunters. The reported bag/hunter/year was 21–23 in the early 1960's and in recent years has been 12–16. Keeler (1977:284) cites parallel evidence for a gradual decline in dove populations throughout the United States. Although the Mourning Dove is a remarkably adaptive game bird it cannot be expected to maintain population levels indefinitely in the face of progressive adverse habitat change.

TABLE 6. Summary of Mourning Dove Call-count Taken Near Turlock, 1966–78. California Department of Fish and Game Data.

	Number of doves heard per 20-stop route			
Year	*Stanislaus-Merced*	*Merced*	*Fresno*	*Mean*
1966	20	4	11	11.7
1967	20	6	5	10.3
1968	32	8	14	18.0
1969	7	7	10	8.0
1970	11	10	7	9.3
1971	13	1	11	8.3
1972	11	2	8	7.0
1973	12	4	1	5.7
1974	19	7	1	9.0
1975	10	10	6	8.7
1976	23	5	16	14.7
1977	19	13	2	11.3
1978	25	10	5	13.3

On the other hand, I see abundant evidence that the urban and suburban dove habitat within the city limits of Turlock itself is improving and enlarging. Residential buildings and their associated plantings offer many favorable nesting sites. Vacant lots, garden plots, small fields, and home bird feeders supply abundant and reliable supplies of food. City doves do not appear to move about the countryside, hence are little exposed to hunting. The Mourning Dove in Stanislaus County is increasingly colonizing urban habitats as it loses ground in rural habitats.

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I am deeply grateful to Dr. A. Starker Leopold of the University of California for his encouragement, suggestions, and aid in writing this report. My thanks also are extended to Gene Christman, who prepared the figures; Nobu Asami, who typed the manuscript; Henry Reeves and George Jonkel of the Bureau of Sport Fisheries and Wildlife, who made available band return records and scientific reports otherwise unavailable to me; Harold Harper and staff of the California Department of Fish and Game for supplying data on various dove studies; and, last but not least, to my wife, Midge, for her patience and assistance.

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STATUS AND DISTRIBUTION OF THE CALIFORNIA CLAPPER RAIL (*Rallus longirostris obsoletus*)

ROBERT GILL, JR
U. S. Fish and Wildlife Service
Anchorage, Alaska

California Clapper Rail population and distributional data were derived from 120 censuses conducted over 5,000 ha (12,350 acres) of greater San Francisco Bay area tidal marshes from February 1971 to December 1975. Breeding populations are restricted to San Francisco Bay, Humboldt, Morro, and Tomales bays, and perhaps Elkhorn Slough, no longer support breeding Clapper Rails. Within San Francisco Bay, major populations exist in San Mateo, Santa Clara, Alameda, and Marin counties and in Napa Marsh.

Breeding and nonbreeding season population densities did not differ significantly within the major population centers of the range. The Clapper Rail population was estimated to be 4,200–6,000 birds during this study. South San Francisco Bay and Napa Marsh supported 55 and 38%, respectively, of the population.

INTRODUCTION

The California Clapper Rail (*Rallus longirostris obsoletus*) was an endemic rallid of most estuarine marshes of central coastal and northern coastal California (A.O.U. 1957). Accelerated loss of habitat after 1900 resulted in significant reductions in both its range and numbers and in its being declared "Endangered" by both the Secretary of the Interior (U.S. Fish and Wildlife Service 1973) and the California Fish and Game Commission (California Department of Fish and Game 1976).

This subspecies has been the subject of numerous studies throughout its range. The resulting literature was recently summarized (Wilbur and Tomlinson 1976). Much of the literature addresses aspects of breeding biology. There are few data regarding the population dynamics of *obsoletus*, and since 1944 there have been no comprehensive reports on its distribution.

Since 1944, approximately 2,832 ha (7,000 acres) of California Clapper Rail habitat have been eliminated through diking, filling, or conversion to salt evaporation ponds, representing a 20% loss in rail habitat. In light of the continuing elimination or alteration of California's estuarine marshes and the continuing threat of major environmental catastrophes, such as oil spills, it becomes critical that current data on endangered species be available to guide protection efforts.

Throughout its range, the California Clapper Rail is restricted to tidal salt marsh that is interspersed with drainage channels inhabited by an abundant invertebrate fauna, including *Modiolus demissus, Macoma balthica, Hemigrapsus oregonesis,* and *Pachygrapsus crassipes*. Principal vegetative dominants of San Francisco Bay marshes inhabited by *R. l. obsoletus* include cord grass (*Spartina foliosa*), pickleweed (*Salicornia* spp), salt grass (*Distichlis spicata*), and gumplant (*Grindelia* spp). Bulrushes (*Scirpus* spp), silverweed (*Potentilla pacifica*), and Baltic rush (*Juncus balticus*) are dominant in Napa Marsh, upper Petaluma River, and along Sonoma Creek. The marshes of Elkhorn Slough, Bolinas Lagoon, and Tomales Bay are predominantly *Salicornia*.

This study, conducted from February 1971 to December 1975 and augmented by more recent data, reports on the historic and current distribution and abundance of the California Clapper Rail. Habitat utilization, limiting factors, and potential range expansions are also discussed.

STUDY AREA

The study was conducted on approximately 5,000 ha (12,350 acres) of the greater San Francisco Bay area tidal marshes, including Elkhorn Slough, Bolinas Lagoon, Tomales Bay, and Suisun Marsh (Figure 1). These tidal marshes have a varied flora (Hinde 1954; Pestrong 1965, 1972; Gerdes 1974; Madrone Associates 1977).

METHODS

Historic distribution and abundance data were collected from published and unpublished literature, including sight records and newspaper accounts. The following collections were searched for specimens and egg sets: MVZ—Museum of Vertebrate Zoology, Berkeley; CAS—California Academy of Sciences, San Francisco; SJSU—San Jose State University, San Jose; LANHM—Los Angeles Natural History Museum; SU—Stanford University; SDNHM—San Diego Natural History Museum; and Western Foundation of Vertebrate Zoology, Los Angeles.

Current distribution, abundance, and habitat requirement data were collected from (1) published and unpublished sight records, (2) surveys by Gould (1973), and (3) 120 censuses conducted in known or suspected rail habitat during the breeding (1 March–31 August) and nonbreeding (1 September–28 February) seasons from 1971 through 1975 (Table 1). These censuses were conducted both jointly and independently by personnel of the California Department of Fish and Game and of the U.S. Fish and Wildlife Service and by volunteers from local Bay Area Audubon Society chapters, universities, and colleges.

TABLE 1. Census Effort, February 1971–December 1975.

	No. of censuses		*Area of coverage*	
County	*Breeding season*	*Nonbreeding season*	*(ha)*	*(%)* *
Monterey	3	2	78	32.1
Santa Cruz	1	1	12	48.0
San Mateo	5	7	396	48.9
Santa Clara	3	8	206	29.9
Alameda	7	18	1,056	87.0
Contra Costa	4	8	202	25.0
Solano	6	5	889	45.3
(Napa Marsh)	(4)	(3)	(420)	(84.0)
(other)	(2)	(2)	(469)	(32.1)
Napa	6	1	465	46.0
Sonoma	8	11	1,161	60.0
(Napa Marsh)	(4)	(5)	(600)	(85.7)
(other)	(4)	(6)	(561)	(45.3)
Marin	5	11	313	43.0
Totals	48	72	4,778	

* Percent of existing marsh habitat censused, by county

Selection of rail census techniques was dictated by vegetative components of marshes throughout the study area, seasonal variations in tide height, and behavioral differences of *obsoletus* between breeding and nonbreeding seasons. Marshes in south San Francisco Bay, Marin County, and Monterey County were most effectively censused during the breeding season by a rope drag method (Gill 1972) and by broadcasting taped Clapper Rail calls. During the non-

breeding period, however, visual censusing during daylight flood tides was most effective. Since flood tides occur only at night during the breeding season, this technique was not used during this period. Flood tides were considered to be tides greater than +6.5 feet MLLW (mean lower-low water) at Fort Point, San Francisco. During flood tides, rails are usually forced to the highest exposed areas of the marsh and become more visible and are easily censused. This is especially true of marshes in south San Francisco Bay which have vegetation of a rather uniform height; these marshes often become completely inundated by flood tides.

Napa Marsh, comprising portions of Napa, Sonoma, and Solano counties, marshes along the Petaluma River, and marshes in west Contra Costa County were effectively censused by eliciting rail calls from taped calls. Taped calls were broadcasted during low or moderately high tides during both breeding and nonbreeding seasons. The height and density of vegetation remaining exposed during flood tides precluded visual censusing by the flood tide method.

Data on habitat use by *obsoletus* were derived from (1) extensive censusing of marsh areas and then projecting these data to other similar and often contiguous habitats, and (2) extensive spot checking of marsh areas not censused to note the presence or absence of rails.

Population densities were projected from average mean densities of breeding and wintering populations censused under similar tide conditions and by similar techniques.

RESULTS

Historic Distribution

Estuarine marshes of San Francisco Bay have historically supported the largest populations of California Clapper Rails. Tidal marsh once covered an estimated 81,000 ha (200,300 acres) along San Francisco Bay (Nichols and Wright 1971) (Figure 1). The marshes along the entire south arm of the Bay in San Mateo, Santa Clara, and Alameda counties were favored by *obsoletus* (Grinnell 1915, Grinnell and Miller 1944, Sibley 1952). Elsewhere in the San Francisco Bay area and along the central California coast, the California Clapper Rail was more restricted in its distribution and probably absent from Napa Marsh until the mid-1930's.

Contra Costa County

Grinnell (1915) made no reference to *obsoletus* occurring in Contra Costa County; however, sightings and specimens from San Pablo were reported by 1919 (Grinnell and Wythe 1927, MVZ 31308). Two specimens (SJSU 3883, 3884) taken in April 1920 near Richmond indicate a possible breeding population at that time. Breeding was also known as late as 1956 near Pt. Isabel (Williams 1957); however, Farrar felt that no California Clapper Rails could be found in Contra Costa County as of 1962 (Cutler and Pugh 1962).

Solano and Napa County

The eastern limit of *R. l. obsoletus* has been reported as Southampton Bay, Solano County (Grinnell and Miller 1944). Other sightings from this area are few, but there are breeding records (Williams 1957, Cogswell 1958), including an egg set from 1948 (E. Stoner, Western Bird Banding Assoc., pers. commun.). Historic records were not found from other parts of Solano County, including Suisun Marsh and portions of the Napa Marsh.

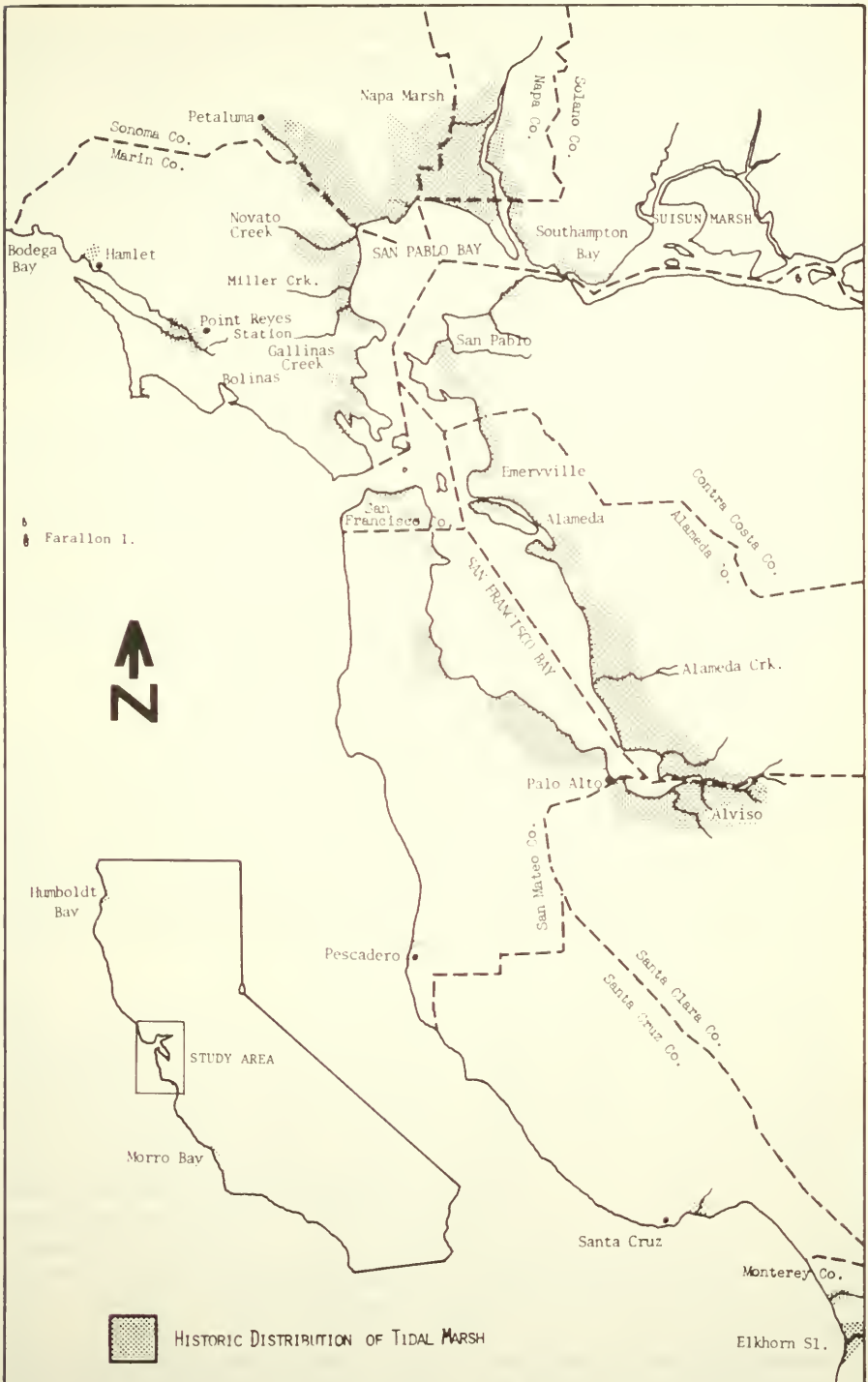

Figure 1. Study area and historic distribution of tidal marsh, ca. 1850 (from Nichols and Wright 1971). The former breeding distribution of the California Clapper Rail included all marsh areas except Napa Marsh.

Sightings or records of California Clapper Rails from Napa County are similarly scarce. A single specimen (SU 10863) is recorded from the "Napa River Valley" in 1939.

Marin and Sonoma Counties

The occurrence of the California Clapper Rail on the San Francisco Bay marshes of Marin and Sonoma counties has apparently fluctuated over the years. Grinnell (1915: 46) felt that *obsoletus* "occurred formerly, 25 or more years ago . . ." in these areas. Grinnell and Wythe (1927) listed a single record from Manzanita, Marin County, in 1920 and described *obsoletus* as occurring "casually" near Petaluma, Sonoma County. By the early 1930's, Jencks (1930) and Bryant (1931) listed several records from Manzanita, including a breeding record in 1930. Breeding is known to have occurred near Greenbrae, Marin County in 1931 (MVZ 7961, egg set).

California Clapper Rails were also known from several coastal marshes in western Marin County. Sight records and specimens exist from Point Reyes Station, Hamlet, and other parts of Tomales Bay (Storer 1915; Brooks 1940; MVZ 24915, 100396; CAS 2234, 1955). Storer (1915) reported a 1914 specimen (MVZ 24915) as the first record of *obsoletus* from the ocean side of Marin County.

San Francisco County

No records of California Clapper Rails were found from San Francisco County other than instances of vagrancy, e.g., the Farallon Islands (Bryant 1888). A population most likely occurred in San Francisco County prior to the late 1880's, by which time almost all marshlands had been reclaimed.

San Mateo and Santa Cruz Counties

The early status of *obsoletus* on coastal marshes of San Mateo and Santa Cruz counties is also unclear as few records were found; none indicated a breeding status. Prehistoric evidence of *R. l. obsoletus* from Santa Cruz County has been found from midden remains north of Santa Cruz (SJSU SCr-7; Matthiesen, San Jose State Univ. pers. commun.). More recently, the species is known from Pescadero Marsh (Orr 1942) and from marshes near Santa Cruz (MVZ 90458, 90459, 90460). These three specimens, all winter records, were taken between 1938–1940 and could have been part of a small resident population or winter dispersals from other areas, such as Elkhorn Slough.

Monterey County

Although Grinnell (1915) questioned the presence of *obsoletus* in the Monterey Bay area, Silliman (1915) reported it as regularly, but sparsely, inhabiting salt marshes of Elkhorn and Tembladero sloughs and other marsh tributaries of Monterey Bay. By 1918 Grinnell described *obsoletus* as occurring in small numbers near Elkhorn Slough (Grinnell et al. 1918). Prior to 1908 it is unlikely that *obsoletus* existed in what is now Elkhorn Slough since the area was a freshwater lagoon and a tributary of the Salinas River. Two years after the 1906 earthquake, the area was cut off from the Salinas River and only then became an estuary capable of supporting *obsoletus* (Browning 1972). Elsewhere in Monterey County, California Clapper Rails were known from Pacific Grove (Kimball 1922), but even then were considered as vagrants.

Other Areas

Outside of the greater San Francisco Bay area the California Clapper Rail has been reported from Humboldt Bay, Humboldt County. Breeding populations

existed in 1932 on Indian Island, Humboldt Bay, and at the mouth of the Mad River, Humboldt County, but no confirmed breeding records have been reported since (Yocom and Harris 1975).

South of Monterey Bay, *obsoletus* has been reported breeding only at Morro Bay, San Luis Obispo County (Brooks 1940). Specimens taken in mid-February 1939 (MVZ 100404, 100405) indicate a possible breeding population at that time. The subspecific identity of these Clapper Rails is still disputed, but it is generally considered to be *obsoletus* (Brooks 1940, Wilbur and Tomlinson 1976).

Early sighting records of California Clapper Rails in the State of Washington were questioned by Dawson and Bowles (1909).

Current Distribution

The California Clapper Rail occupies approximately 60% (5,650 ha or 13,950 acres) of the estuarine marsh within its current range (Table 2). The present breeding distribution of the California Clapper Rail is now apparently confined to the greater San Francisco Bay area (Figure 2).

Apparently this rail no longer breeds in Humboldt County or Morro Bay. Several reports of this species from both areas in recent years indicate that *obsoletus* may still occur there, most likely as vagrants (Yocom and Harris 1975, Wilbur and Tomlinson 1976). Very recently, a Clapper Rail was heard calling from a marsh in Morro Bay in April 1977 (Tim Manolis, pers. commun.).

TABLE 2. Available Tidal Marsh and Amount Utilized by the California Clapper Rail in Its Present Range.

	Amount of tidal marsh				
	Available		*Utilized*		
County	*(ha)*	*(%)*[1]	*(ha)*	*(%)*[2]	*(%)*[3]
Monterey	243	2.6	206	84.7	3.6
Santa Cruz	25	0.3	0		
San Mateo	809	8.6	750	92.7	13.3
Santa Clara	688	7.3	421	61.2	7.5
Alameda	1,214	12.9	995	81.9	17.6
Contra Costa	809	8.6	252	31.2	4.5
Solano	1,963	20.8	458	23.3	8.1
(Napa Marsh)	(500)	(5.0)	(458)	(91.6)	(8.1)
(other)	(1,463)	(16.0)	(0)		
Napa	1,012	10.7	816	80.6	14.4
Sonoma	1,936	20.5	1,435	74.1	25.4
(Napa Marsh)	(700)	(7.4)	(615)	(87.8)	(10.8)
(Petaluma River)	(1,236)	(13.1)	(820)	(66.3)	(14.5)
Marin	728	7.7	319	43.8	5.6
Totals	9,427	100.0%	5,652		100.0%

[1] Percent of available habitat throughout the subspecies range
[2] Percent of available habitat utilized in each county
[3] Percent of habitat utilized throughout the range

Monterey County

Until recently, California Clapper Rails were considered to be resident in Elkhorn Slough, occurring from approximately 300 m (1,000 ft) west of State Highway 1 to Kirby Park. From 1966 to 1969 several were observed north of Kirby Park, including adults with young (D. Pine, biologist, Calif. Dept. Fish and Game, pers. commun.). Varoujean (1973) did not find any north of this area in 1972, and at that time he estimated a minimum population of 14 birds for Elkhorn Slough. However, no Clapper Rails were found in the slough in special

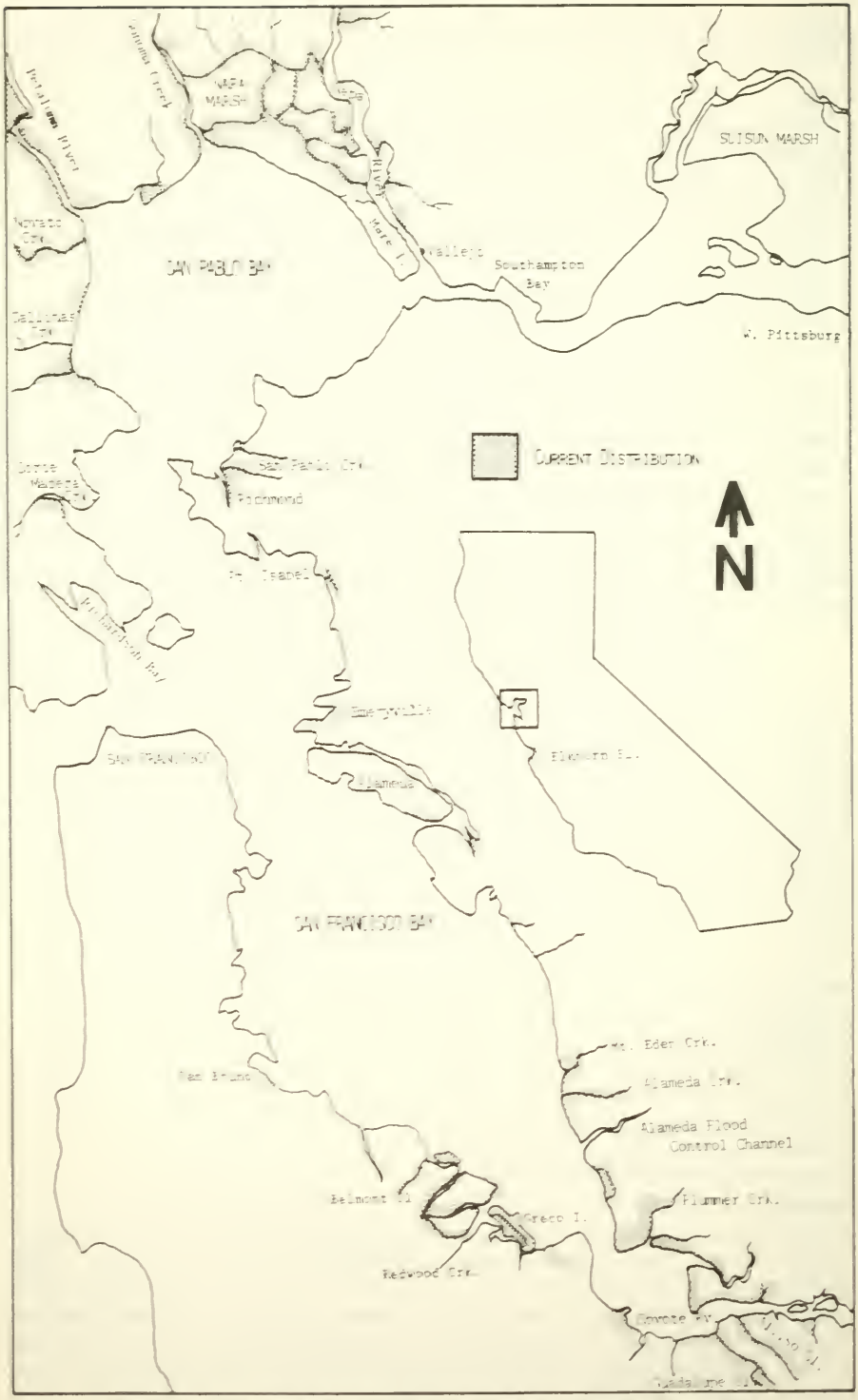

Figure 2. The current breeding distribution of the California Clapper Rail

rail surveys at high tides in December 1977 and April 1978, although one bird had been sighted here in March 1978 (R. Jurek and A. Craig, biologists, Calif. Dept. Fish and Game, pers. commun.). Records of *obsoletus* away from Elkhorn Slough include birds seen at the mouths of the Salinas and Carmel rivers in summer (R. Stallcup, Western Field Ornithologist and V. Yadon, Director, Pacific Grove Mus. of Nat. Hist., pers. commun.; Arbib 1972*a*) and on the Monterey Peninsula in winter (Arbib 1971, 1972*b*).

Santa Cruz County

No resident population is known. Specimens or sight records have not been reported since 1940. Small marshes along several coastal drainages could attract vagrants or dispersing juveniles from Elkhorn Slough, Monterey County.

San Francisco County

No resident population exists. Virtually all estuarine marsh has been eliminated.

San Mateo County

California Clapper Rails breed in Bay marshes from south San Francisco to the county line near Palo Alto. Greco Island, Bair Island, and marshes bordering Redwood Creek, Westpoint, Corkscrew, Smith, Steinberger, and Belmont sloughs, plus marshes south of Cooley Landing provide most of the remaining habitat. Small marshes near San Bruno Point and Burlingame support small but stable populations. Eventually, the Clapper Rail can be expected to inhabit those areas of Bair Island now being restored to tidal marsh.

Santa Clara County

Major populations are found within the marshes of the Palo Alto Baylands Nature Interpretive Center at the mouth of Charleston Slough, and along the larger fringing marshes of Guadalupe and Alviso sloughs. They also occur from the mouth of Alviso Slough east to the abandoned town of Drawbridge. Breeding is not known east of Drawbridge; however, during this study, several winter sightings have come from this area.

Alameda County

Populations of Clapper Rails occur along all fringing marsh from Mud Slough to the Dumbarton Bridge, including Mowry Slough, Newark Slough, and the salt marsh along Plummer Creek. Also, they occur from approximately 1 km (0.6 mile) north of the Dumbarton Bridge to the mouth of Mt. Eden Creek and along Old Alameda Creek upstream approximately 2 km (1.2 miles). They are absent from the recently created Alameda Flood Control Channel but can be expected to inhabit this area once suitable habitat develops. North of Mt. Eden Creek, populations are limited and confined to Arrowhead Marsh in San Leandro Bay, Alameda South Shore, and marshes adjacent to the San Francisco-Oakland Bay Bridge.

Contra Costa County

Remnant breeding populations occur in salt marshes along Wildcat and San Pablo creeks. Small, scattered populations occur between San Pablo Creek and Point Pinole and most likely still occur in the remnant marshes east of Point Isabel. They are not known to breed elsewhere in the county. I consider sightings from west Pittsburg (March 1964) and Frank's Tract (September 1963) (Lynn Farrar, pers. commun.) to be dispersing young, possibly from Southampton Bay, but more likely from Napa Marsh.

Solano County

Resident populations occur along portions of Dutchman, South, and China sloughs within Solano County. They also occur from the mouth of White Slough and fringing marshes from approximately 1 km (0.6 mile) south of the Vallejo Bridge north to Slaughterhouse Point. *Obsoletus* is apparently absent from Mare Island and the broad *Salicornia* marsh fronting San Pablo Bay. There have been no breeding records of Clapper Rails from Southampton Bay since 1958; however, the species was heard calling from this area on two occasions in late March 1977 (T. Manolis and F. Beyer, Napa-Sonoma Audubon Soc., pers. commun.). The Clapper Rail is absent from Suisun Marsh and eastern Solano County.

Napa County

They are resident and breed along Devil, South, China, Napa, Mud, Fagan, and Steamboat sloughs. They also occur within the marshes of Fly Bay, Coon, and Edgerly islands, and along the marshes of the Napa River from the Napa-Solano county line north to Bull Island.

Sonoma County

Clapper Rails breed within the marshes of Napa, Hudeman, Steamboat, and Second and Third Napa sloughs. They also occur in low numbers along Sonoma Creek to Wingo, along the Petaluma River to Schultz Creek, and on Lower Tubbs Island (Gould 1973). Apparently they are now absent from upper Tolay Creek.

Marin County

On the San Pablo Bay shores of Marin County the Clapper Rail is common and breeds from the mouth of Novato Creek south to the mouth of Gallinas and Miller creeks and upstream along these drainages for approximately 0.5 km. (0.3 mile). They occur in small numbers along Novato Creek upstream to 2 km (1.2 miles) north of State Highway 37. Small numbers are also found from the mouth of Corte Madera Creek upstream to State Highway 101, and from the mouth of San Rafael Creek upstream approximately 1 km (0.6 mile). Apparently the Clapper Rail is absent from Richardson Bay, the last sighting from this area being in 1967 (R. Stallcup, pers. commun.). At that time the population was confined to marshes near Mill and Tamalpais valleys and was estimated to be fewer than six birds. There have been two sightings of *obsoletus* from coastal Marin County (Bolinas Lagoon) since 1970 (P. Hendersen, biologist, Point Reyes Bird Observatory, pers. commun.; Gould 1973).

Historic and Current Abundance

Quantifiable data on the historic abundance of the California Clapper Rail are meager. The earliest published accounts of rail abundance refer only to numbers taken from local areas for commercial or sport use and do not relate to population densities or numbers supported by a given area. It can, however, be inferred from some of these early accounts that thousands of California Clapper Rails inhabited the south arm of San Francisco Bay alone. A newspaper account from the *San Mateo Leader* of October 23, 1897, referred to at least 5,000 "rails" killed during a 1-week period that year. Similar reports between 1890–1910 of individual hunters killing 30 to 50 rails a day are not uncommon (*Redwood City Times-Gazette* and *San Mateo Leader* 1890–1910). The majority of these were undoubtedly Clapper Rails as concern over the killing of such numbers of "rails" during this period led to immediate enactment of laws regulating Clapper Rail hunting.

Population studies of Clapper Rails in south San Francisco Bay by Applegarth (1938) and Zucca (1954) provide the only comparable data on population densities during the breeding and nonbreeding seasons. Applegarth reported breeding densities of 1.59, 4.35, and 1.69 rails/ha for three 4-ha (10-acre) study plots in 1937. Zucca, censusing during flood tides, found densities in winter of 2.37 and 2.92 rails/ha for a 26-ha (63-acre) study area in 1950 and 1951.

I found mean densities in utilized habitat over the five major population centers in San Francisco Bay to range from 0.3 to 1.6 rails/ha during the breeding season, and from 0.1 to 1.1 rails/ha during the nonbreeding season (Figure 3). A test for the comparison of means of samples of unequal variance revealed no significant difference (all $p > 0.05$) between breeding and nonbreeding season densities over a given area. The population projection for each area, therefore, is based on the average of the mean densities for the breeding and nonbreeding seasons (Table 3).

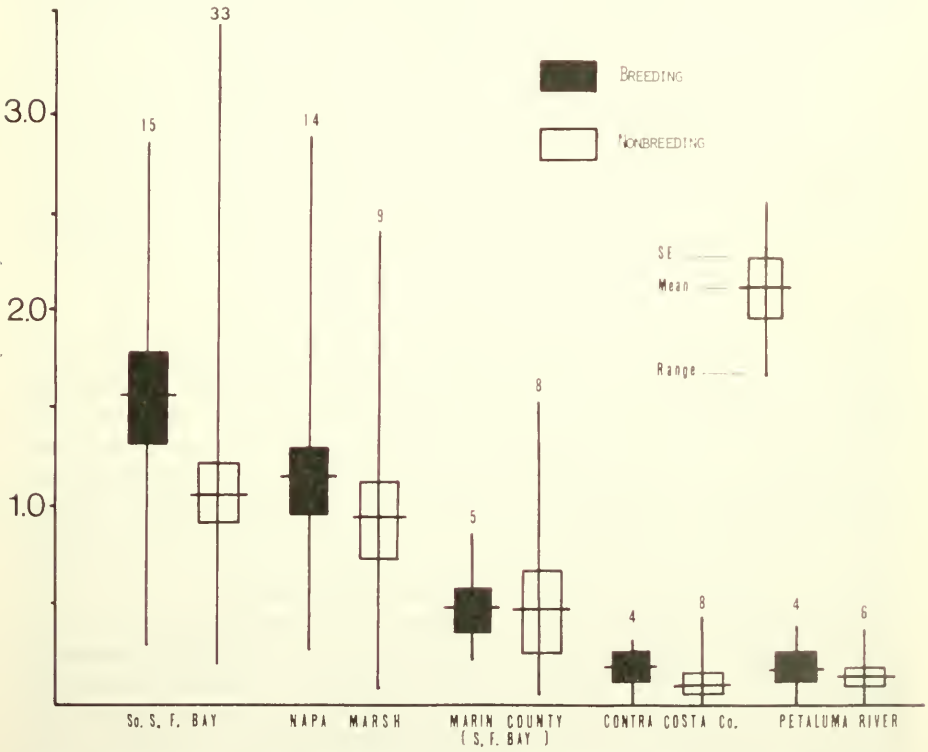

Figure 3. Breeding and nonbreeding season densities of the California Clapper Rail over major population centers throughout San Francisco Bay, 1971–1975. Number of censuses is shown above each area.

DISCUSSION

The present range of the California Clapper Rail has become extremely fragmented as a result of habitat elimination and alteration. South San Francisco

Bay continues to be the major population center, while only isolated populations remain along the Contra Costa County shoreline. The San Pablo Bay marshes in Marin County support a small but stable population. The population in Elkhorn Slough apparently has declined since 1972 and may no longer exist. Napa Marsh now supports a much larger population than in past years. This is interesting, considering that prior to 1940 only two references could be found to Clapper Rails occurring in Napa Marsh and that as late as 1952 major portions (1,800 ha) of the marsh had been converted to salt evaporation ponds, thereby eliminating a major rail population, if, in fact, one existed. When considering the extent of Clapper Rail studies and specimen collections elsewhere in San Francisco Bay prior to 1940, it seems unlikely that a population of the present size went unnoticed for so long. I consider the Napa Marsh population to be a relatively recent range extension, probably resulting from a change from a mostly freshwater marsh to a more brackish one due to substantial decreases in freshwater inflow to the marsh.

TABLE 3. Average Yearly Population of California Clapper Rails over Major Population Centers of the Range, 1971–1975.

Area	*Utilized habitat (ha)*	*Density (birds/ha)*	*Population projection*	*Range*[1]
Elkhorn Slough, Monterey County	206		14	14 (minimum)[2]
So. San Francisco Bay	2,166	1.31	2,837	2,415–3,249
W. Contra Costa County	252	0.14	35	20–50
Napa Marsh	1,889	1.04	1,964	1,605–2,304
Petaluma River	820	0.17	139	86–184
Marin County (San Francisco Bay)	319	0.48	153	102–204
Totals	5,652		5,142	4,242–6,005

[1] Range is ± one S.E. about the mean.

[2] From Varoujean (1972). No range given.

Within its former range, *obsoletus* can be expected to inhabit most areas being restored to tidal marsh. Extensions into areas not historically inhabited by *obsoletus* will probably be limited to Suisun Marsh, marshes along the north shore of Contra Costa County, and possibly other portions of the Sacramento-San Joaquin Delta. It is conceivable that with the future planned reductions in outflow from the Delta river system, there will be a corresponding change in benthic fauna and marsh flora as the salinity gradient increases and moves east (Skinner 1972). This change toward a more saline marsh would probably provide all the requirements necessary to support populations of *obsoletus*.

Since the mid-1960's the overall population of California Clapper Rails has remained relatively stable. However, during this study I noticed that portions of the population, especially in south San Francisco Bay, exhibited fluctuations similar to those reported for *R. l. creptans* along the east coast of the United States, where intraspecific competition for nesting territory is thought to be a major factor governing population levels (Ferringo 1966, Widjeskog 1974). There, the principal cause of territorial conflict and subsequent population fluctuations is successive years of high rail production because of a lack of normally disruptive high tides during the nesting period. Ferringo (1966) also felt that a period of drought, superimposed on the above conditions, resulted in increased nest loss and chick and adult mortality.

While high tides might be a factor in limiting populations of *obsoletus* (Zucca

1954), I feel a more important factor contributing to population fluctuations is a change in biomass, production, and relative composition of *Spartina* and *Salicornia,* the preferred nesting habitats of *obsoletus* throughout most of its range. This occurs as a result of changes in soil and water salinities which, in turn, are determined by weather and seasons (Cameron 1972. Mahall and Park 1976*a,* 1976*b).*

Mahall and Park (1976b), during a study of plant zonation in salt marshes in San Pablo Bay in 1972–1973, found *Spartina* to be much less tolerant than growth of *Spartina.* They noted, following the extremely dry winter of 1971–1972, a reduction in both biomass and net productivity of *Spartina* the following spring, and after the extremely wet 1972–1973 winter they observed a faster growth of *Spartina* in spring.

Assuming that *Spartina* and *Salicornia* were similarly affected in marshes in adjacent south San Francisco Bay, there would have been a decrease in *Spartina* biomass in 1972 and, thus, an overall reduction in the amount of nesting habitat available that season. This would have increased intraspecific competition for nesting territories in adjacent *Salicornia* and less used nesting cover such as *Grindelia.* This may have accounted for the approximately 40% reduction in rail numbers in 1972 compared with the higher numbers found during the 1971 season when *Spartina* was heavily used as nesting cover (Gill 1973, 1977).

These fluctuations in *Spartina* biomass and productivity might also account for the variations in preferred nesting habitat reported by other investigators during studies of *obsoletus* in similar marsh areas, (and, in two instances, the same marsh area) in south San Francisco Bay (DeGroot 1927, Applegarth 1938, Zucca 1954, Gill 1973).

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NOTES

ARCHAEOLOGICAL EVIDENCE CONCERNING THE PREHISTORIC OCCURRENCE OF SEA MAMMALS AT POINT BENNETT, SAN MIGUEL ISLAND

Beyond their importance in assesssing the nature of human subsistence activities, archaeological remains also can provide information concerning the biology of animal species utilized by prehistoric human populations. Faunal remains from archaeological sites on San Miguel Island are of particular importance in this respect since they are the only source of information currently available concerning the recent history of the exceptionally diverse assemblage of sea mammals which presently inhabit the island. The objective of this report is to provide data concerning the structure of the San Miguel sea mammal community prior to the decimation caused by the commercial fur trade of the 18th and 19th centuries.

Data relating to the prehistoric abundance of seals, sea lions, and sea otters was obtained through an analysis of faunal remains recovered from archaeological excavations conducted by Charles Rozaire of the Natural History Museum of Los Angeles County (LACM) on San Miguel Island at the site SMI-525 (Rozaire 1965). This archaeological site is located directly above the present sea mammal rookery on the west end of San Miguel Island at Point Bennett. Two 5-ft^2 pits were excavated in this stratified shell midden to a maximum depth of approximately 12 ft. Although no radio-carbon dates are available from the site, relative dating of artifacts recovered indicates that part of the deposit represents an occupation dating from at least 1000 years before the present. Although the duration of occupation is unknown, use of the portion of the site excavated by Rozaire apparently terminated before the historic period since no post-contact (16th century) artifacts were recovered.

Osteological remains from SMI-525 were identified using comparative material from LACM; the California Academy of Sciences; the University of California at Berkeley; the Santa Barbara Museum of Natural History; the United States Geological Survey, Menlo Park; and the Department of Anthropology, University of California at Santa Barbara.

The minimum number of individuals from each stratum were computed by tabulating the most frequently occurring unique skeletal element for each species (Table 1). Whenever possible, individuals included in the count of minimum number of individuals were classified as adult or sub-adult (Table 2). Adults were distinguished from sub-adults using a variety of criteria which included extent of dental attrition, annular rings on the teeth, epiphyseal fusion, and long bone dimensions. Since there is selective retardation in the fusion of long bone epiphyses in sea mammals (Versaggi, pers. commun.), this criterion was used with considerable caution in the identification of adults. In general, if both proximal and distal epiphyses were securely attached to the diaphysis the individual was considered to be adult.

Since faunal remains from SMI-525 are a product of human subsistence activity, they cannot be considered an unbiased sample of the sea mammal populations living prehistorically in the vicinity of San Miguel Island.

TABLE 1. Sea Mammal Remains From SMI-525 at Point Bennett, San Miguel Island

Minimum number of individuals

Depth in inches	*Arctocephalus townsendi*	*Zalophus californianus*	*Eumetopias jubata*	*Callorhinus ursinus*	*Mirounga angustirostris*	*Phoca vitulina*	*Enhydra lutris*
18– 24	3	2			1		1
24– 30	4	1					1
30– 36	3	2	1		1	1	2
36– 42	4	4	1		1	1	2
42– 48	5	1		2	1	1	2
48– 54	5	1				2	4
54– 60	2	2		1	4		1
60– 66		2					
66– 72							
72– 78	3	3				1	2
78– 84	3						1
84– 90	3	2					2
90– 96	4	2	1			1	1
96–102	2	1	1	1	1	1	1
102–108	1						1
108–114	1	1			1		1
114–120	1	1				1	1
120–126		2			1		1
126–132	2						1
132–138							1
TOTAL	46	27	4	4	11	9	26

TABLE 2. Distribution of Age Classes Present in the Sea Mammal Remains from SMI-525 at Point Bennett, San Miguel Island

Minimum number of individuals

	Arctocephalus townsendi		*Zalophus californianus*		*Eumetopias jubata*		*Callorhinus ursinus*		*Mirounga angustirostris*		*Phoca vitulina*		*Enhydra lutris*	
Depth in inches	*Adult*	*Sub-Adult*	*Adult*	*Sub-Adult*	*Adult*	*Sub-Adult*	*Adult*	*Sub-Adult*	*Adult*	*Sub-Adult*	*Adult*	*Sub-Adult*	*Adult*	*Sub-Adult*
18– 24	2	1		2						1			1	
24– 30	1	3	1										1	
30– 36	2	1	1	1		1				1	1		1	1
36– 42	2	2	2	2	1				1			1	2	
42– 48	2	3	1				1	1		1		1		2
48– 54	2	3	1								1	1	3	1
54– 60	1	1	1	1				1	1	3			1	
60– 66														
66– 72			1	1										
72– 78	1	2	1	2								1	1	1
78– 84	1	2												1
84– 90	1	2	1	1									1	1
90– 96	1	3	1	1	1						1		1	
96–102	1	1	1			1		1		1		1	1	
102–108		1												1
108–114		1	1										1	
114–120			1							1	1		1	
120–126		1	1	1						1			1	
126–132	1	1											1	
132–138														1
TOTAL	18	28	15	12	2	2	1	3	2	9	4	5	17	9

Human selectivity in respect to species taken, age of selected animals, and cultural biases in processing prey species all influence the composition of accumulations of faunal material in archaeological sites. Biases in the composition of faunal assemblages, however, are not unique to archaeological proveniences. The skewing effects of predation, differential deposition, and variable preservation also influence the distribution of animal remains from paleontological deposits which are not the product of human activity (Shotwell 1955). Despite uncertainties concerning sampling biases, faunal remains can yield useful information relating to the past distribution of animal species exploited by humans.

Although all of the pinniped species currently utilizing San Miguel Island are represented in the site material, the relative frequency of certain species differs significantly from what would be predicted from their present abundance on the island. The remains of the Guadalupe fur seal, *Arctocephalus townsendi,* were more abundant than any other species recovered. This abundance is in sharp contrast to the present marginal status of the species on San Miguel Island which is a result of commercial sealing activities that reduced the species to a relict population centered around Guadalupe Island, Baja, California. DeLong (1975) reports that one female and several adult and sub-adult males have periodically appeared on Point Bennett since 1968. During 1973 and 1974, a single adult male secured a territory at Point Bennett, displacing California sea lions, *Zalophus californianus.* The relative frequency of *Arctocephalus* remains at SMI-525 is consistent with data from other archaeological proveniences in the Santa Barbara Channel area which indicates that *Arctocephalus* was more abundant than any other pinniped species prior to European contact (Lyon 1937).

The remains of California sea lions were more frequent in the site material than those of any other sea mammal except the Guadalupe fur seal. At present California sea lions are by far the most abundant pinniped on San Miguel Island. Although recent estimates place the island's total *Zalophus* population at between 15,000 and 20,000 animals (DeLong 1975), this abundance is a recent development which has resulted from an exponential increase in the size of the California sea lion populations in the Channel Islands since the 1930's (Bartholemew 1967).

In contrast to California sea lions, the size of the Stellar sea lion, *Eumetopias jubata,* population, which peaked at around 2000 individuals in the late 1930's on San Miguel Island, has been steadily decreasing during the past 30 years (Bartholomew 1967). At present the *Eumetopias* population on San Miguel Island is composed of fewer than 100 animals (Bartholomew 1967; DeLong 1975). The relative frequencies of *Zalophus* and *Eumetopias* remains in the various levels of the SMI-525 excavations indicate that *Eumetopias* in the vicinity of San Miguel Island probably had a marginal status throughout a considerable portion of the Island's prehistoric occupation (Table 1). We feel that the relative frequencies of *E. jubata* and *Z. californianus* in the deposit accurately reflect their past abundance for the following reasons: (i) At present, the terrestrial breeding periods of the two species nearly co-occur on the Point Bennett rookery; (ii) There is no ethnohistoric or archaeological evidence that *Zalophus* was preferentially hunted; and (iii) Steller sea lions are encountered infrequently in other prehistoric archaeological deposits from the Channel Islands (Lyon 1937).

The remains of harbor seals, *Phoco vitulina;* northern elephant seals, *Mirounga angustirostris;* and northern fur seals, *Callorhinus ursinus,* were infrequent in

the faunal remains from SMI-525. The paucity of harbor seal remains is not unexpected since these animals often bear their young in the surf zone and have no extensive period of terrestrial breeding activity which would make them accessible to prehistoric hunters.

Hunting difficulty probably does not account for the infrequent occurrence of *C. ursinus* and *M. angustirostris* remains in the deposit. Both of these species experience extended periods of terrestrial breeding activity during which they are extremely susceptible to human predation. The fact that these animals are easily hunted is documented abundantly by the success of 18th and 19th century sealers (Scammon 1874).

The remains of sea otters, *Enhydra lutris,* are nearly as abundant as those of California sea lions in the SMI-525 material. Early Spanish accounts indicate that prestige value was attached to sea otter pelts by the aboriginal inhabitants of the Channel Islands area (King 1971; Woodhouse, Cowen, and Wilcoxon 1976). This cultural factor may have resulted in relatively high levels of prehistoric sea otter exploitation. Because of this potential cultural bias, it is unlikely that the relative frequency of otter remains recovered accurately reflects the prehistoric abundance of the species.

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Phillip L. Walker and Steven Craig, Department of Anthropology, University of California, Santa Barbara, California. *Accepted for publication January 1977.*

AMBICOLORATION IN THE BLACK ABALONE, *HALIOTIS CRACHERODII* LEACH

A review of the recent abalone literature suggests that the black abalone, *Haliotis cracherodii* Leach, 1817, is distinctive, showing variation to a lesser degree than other members of the family (Cox 1960, 1962; Owens 1961; Owens, McLean, and Meyer 1971; Talmadge 1955, 1977). There have been no reports of ambicoloration or morphological "odd-balls" in this species. Owens *et al.* (1971), who recognize 12 hybrids of southern California *Haliotis*, report that *H. cracherodii* is the only eastern Pacific member of this family not known to hybridize.

On October 15, 1975, a live *H. cracherodii*, best described as albino or at least colorless, was collected intertidally by R. W. Richardson near Double Rock, San Luis Obispo County, California. The specimen (Figure 1), measuring 92 x 69 x

25 mm (shell dimensions) and weighing 132 g, varies from the species description only in mantle coloration.

FIGURE 1. Ventral view of ambicolored black abalone, showing a portion of foot, mantle, and epipodium. *Photograph by the author.*

In contrast with the normally smooth black body of *H. cracherodii*, the epipodium and mantle of this specimen were whitish to cream yellow. The eyes also lacked color. The only color on the external surface of the body was the dark appearance of the creases on the foot caused by accumulation of debris. Examination of the mantle cavity and viscera revealed normal coloration, and the specimen was found to be a female. The animal has been kept alive in aquaria at Pacific Gas and Electric Company's Diablo Canyon Biology Laboratory.

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David W. Behrens, Pacific Gas and Electric Company, Biology Laboratory, P.O. Box 117, Avila Beach, CA 93424. *Accepted for publication January 1977.*

EFFECTS OF A CALIFORNIA-DERIVED STRAIN OF *TRICHOMONAS GALLINAE* ON COLORADO BAND-TAILED PIGEONS

Band-tailed pigeons (*Columba fasciata*) are important and highly sought game birds in states of the Pacific Coast region (Jeffrey 1977). Two major populations exist north of Mexico, with the Interior race (*C. f. fasciata*) occurring primarily in the states of Arizona, Colorado, New Mexico, and Utah, with the more abundant Coastal race (*C. f. monilis*) occurring primarily west of the Sierra and Cascade crests in California, Oregon, Washington, and into southwestern British Columbia (Braun, Brown, and Zapatka 1975).

Outbreaks of trichomoniasis in band-tailed pigeons, caused by the protozoan flagellate *Trichomonas gallinae*, are poorly documented, with no naturally occurring deaths reported for the Interior race. Stabler and Herman (1951) documented trichomoniasis in band-tailed pigeons from Monterey and Inyo counties in California in the late 1940's. Merton Rosen (Calif. Dept. of Fish and Game, pers. commun.) also verified the presence of trichomoniasis in band-tailed pigeons obtained from various localities in California over a period of years. Because of the apparently significant numbers of band-tailed pigeons found moribund or dead with suspected trichomoniasis within 160 km (100 miles) north and south of Pebble Beach, California, in 1974 and 1975 (personal communication from G. Gerdes, R. Gutiérrez, M. Rosen, and the late F. John Ward), attempts were made to obtain specimens of pigeons with living *T. gallinae* to confirm the virulence of the particular strain. Through the efforts of F. John Ward we received a moribund band-tailed pigeon from Pebble Beach, California. Earlier papers (Stabler 1950, 1951; Stabler and Matteson 1950) reported on the incidence of *T. gallinae* in band-tailed pigeons in Colorado, while Sileo and Fitzhugh (1969) reported on the incidence of this parasite in bandtails from Arizona. More recently we (Stabler and Braun 1975) experimented with virulent strains of *T. gallinae* in captive band-tailed pigeons trapped in Colorado.

METHODS

Free-living wild band-tailed pigeons of the Interior race were trapped near Colorado Springs, Colorado. Trichomonads used were of the suspected virulent strain of *T. gallinae* isolated from the band-tailed pigeon from Pebble Beach, California. Inoculations were made directly from domestic pigeon carriers of this strain or from dead bandtails killed by it. Two *Trichomonas*-negative bandtails were infected with a nonvirulent strain of *T. gallinae* from a domestic pigeon (*Columba livia*). Inoculations involved pipetting 5,000–10,000 flagellates into the recipients' mouths. Emtryl (Stabler and Kitzmiller 1967) was used to eliminate the trichomonads from a naturally infected bandtail

RESULTS AND DISCUSSION

Trichomonas-negative band-tailed pigeons. Twelve bandtails (eight adults and four immatures) were inoculated from domestic pigeon reservoirs of the virulent trichomonad. The adults died on day 19 (av.) post-inoculation, the immatures on day 15 (av.). Four bandtails (two adult and two immatures) were inoculated from bandtails killed by the virulent strain. The adults died on days 16 and 24, the immatures on days 4 and 16.

Trichomonas-positive band-tailed pigeons. Two adult bandtails infected with avirulent *T. gallinae* of domestic pigeon origin were inoculated, the first with virulent flagellates from the reservoir pigeons, the second with trichomonads from a dead bandtail. The former died on day 10, the latter on day 11.

Five bandtails with natural *T. gallinae* infections were variously inoculated with the virulent strain. Two adults given parasites from a dead bandtail died on days 11 and 13. One immature bandtail given virulent trichomonads from a domestic pigeon reservoir died on day 13. One positive adult, also inoculated from a domestic pigeon reservoir, was alive and well when sacrificed 34 days later.

A naturally infected bandtail was cleared of its infection with Emtryl. Had this bird's parasites produced a premunitive state it should have shown some immunity. Given trichomonads from a dead bandtail, it died on day 8.

It appears that no matter whether the recipient bandtail was an adult or an immature, whether it was free of *T. gallinae* or was already infected, whether the virulent organism was derived from a domestic pigeon carrier or from the body of a dead bandtail, the Colorado race of the band-tailed pigeon is highly susceptible to a strain of *T. gallinae* isolated from a moribund bandtail of the Coastal race from Pebble Beach, California. Obviously, the strain of *T. gallinae* present in some band-tailed pigeons in the Pebble Beach area of California in 1974–75 was virulent and could have caused the dead and moribund pigeons found throughout that area in that time interval. Because of the frequent reports of pigeons dead or dying in the Monterey region from suspected trichomoniasis over a long period (Stabler and Herman 1951; G. Gerdes, M. Rosen, and F. J. Ward, personal communications), and the importance of this region for migrating and wintering band-tailed pigeons of the Coastal race, it would appear to be desirable to study further the role of *T. gallinae* as a mortality factor of this species.

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Robert M. Stabler, Colorado College, Colorado Springs, Colorado, 80903 and Clait E. Braun, Colorado Division of Wildlife, Fort Collins, Colorado 80522. *Accepted for publication July 1977.*

A SIMPLE, RAPID METHOD FOR MARKING INDIVIDUAL SEA URCHINS

INTRODUCTION

The importance of the sea urchin, *Strongylocentrotus* spp, in the ecology of the southern California kelp bed community (Jones, Leighton, and North 1966; Paine and Vadas 1969) has prompted the development of tagging techniques for long-term population studies. Various spine tags have been used for short periods (Sinclair 1959; Vacquier 1964), but tag life is limited to a few weeks. Further, the manipulative difficulty of *in situ* tagging techniques (Lees 1968) led to a search for a more rapid and efficient procedure. The method described herein proved to be fast, easy, inexpensive, and did not require that sea urchins be removed from their rocky substratum.

The core of the method is a textile marker tag made of nylon. Thorson (1967) reported the use of such tags to mark fish, and his report should be consulted for a description of the tags and applicator. The technique presented here utilizes similar equipment to bore a hole in the test and to anchor the tag by fixing it in place with a silicone rubber seat. The tag bears a vinyl disc marked with an identification number (Figure 1).

MATERIALS AND METHODS

Three-inch nylon tags, common in the textile industry, were used. The unmodified tags were one-piece, consisting of a tab and a "T" bar joined by a long, thin shaft (Figure 1). A "Swiftacher" [1] tagging gun (applicator), "Swiftachment fasteners" (tags), and tagging needles were purchased from Dennison Eastman Corporation. The index finger grip on the handle of the tagging gun was removed to minimize spine contact during the tagging procedure.

Tags were prepared in groups of no more than 10 to facilitate handling and to prevent tangling while tagging. A lead fishing sinker, size "BB," was crimped tightly midway on the shaft of each tag. A small conical seat made of RTV 108 (General Electric silicone sealant) was formed beneath each sinker and dusted with powdered calcium carbonate to facilitate tag handling while curing.

Tags were numbered with round plastic identification discs, 2.5 cm (1 inch) in diameter, constructed of 0.05-cm (0.02-inch) white "matte vinyl." Identifying

[1] Use of trade names does not constitute endorsement

numbers were drawn on both sides of the disc with a black permanent marker (Sanford's "Sharpie," No. 3000). Then, a thin coat of clear RTV 108 was smeared on the disc to limit algal growth and marker fade. The tab was folded and inserted through a 4-mm (0.16-inch) off-center hole in the disc, stringing the disc on the tag shaft.

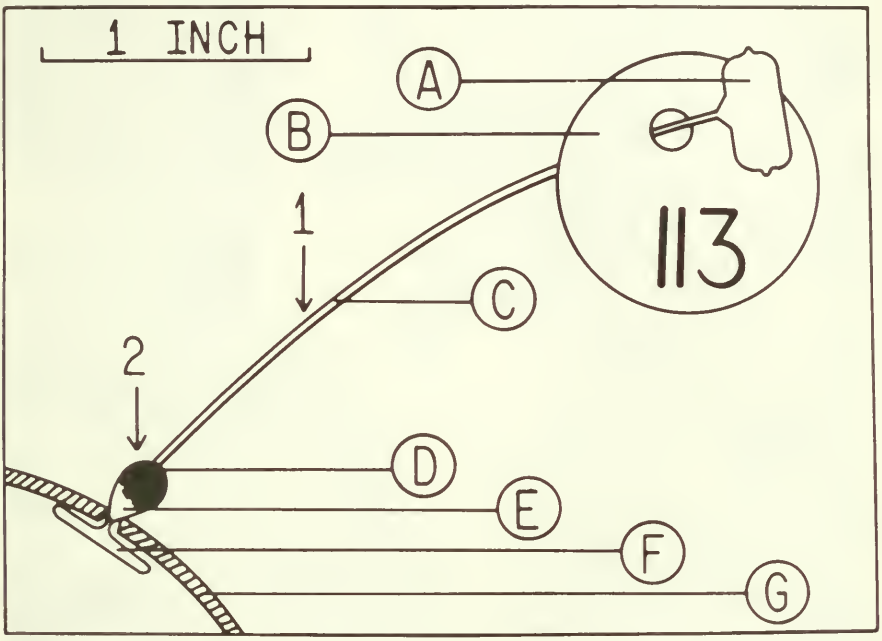

FIGURE 1 Sea urchin tag in position in the test. The components of the tag are (A) tab; (B) identification disc; (C) shaft; (D) lead sinker; (E) RTV silicone seat; (F) "T" bar; (G) sea urchin's test. The sinker is in position 1 before tagging, and as shown, in position 2 after tagging.

The tag is attached to the urchin by placing the tagging needle against the urchin and, while applying light pressure, rotating the gun back and forth through an angle of about 90° with a drilling motion until the test is perforated (Figure 2). Internal scar tissue formed most readily around the "T" bar when the sea urchin was tagged at the ambulacral-interambulacral plate interface. With care, needles last through 50 taggings. Pressure must be maintained against the urchin while the tag is being inserted or the gun will be forced away from the hole. The actuating level on the tagging gun should be kept depressed while the gun is withdrawn. The tag is then pulled tight, away from the urchin, while needle-nose pliers are used to slide the sinker and the silicone rubber seat down the shaft against the urchin, thereby sealing the hole and pinning the tag in place. Minimal spine damage may occur during tagging. An effort was made to place the tag as far from the oral-aboral axis of the urchin as was possible without moving the urchin.

FIGURE 2. Tagging *Strongylocentrotus franciscanus in situ.* The tagging needle has penetrated the sea urchin's test and depression of the actuating level will insert the tag. Note the tagged sea urchin in left foreground. *Photo by Fred Fischer.*

RESULTS AND DISCUSSION

We tagged 150 giant red sea urchins, *Strongylocentrotus franciscanus,* in January 1976, off La Jolla, California (Figure 3). We employed a tagging rate of one sea urchin every 2 min and at a tag cost of less than five cents per urchin. Reobservation data were collected on 40 sea urchins. All data points in the graph were derived from actual observations within the test area; hence some sea urchins were not accounted for owing to movement from the test area or unrecovered fatalities.

Test recalcification in the area of the tag was not observed in any of the sea urchins tagged by this method. However, one sea urchin, tagged without an identification disc, was removed months after tagging with no apparent ill effects. Many urchins showed signs of test decalcification or thinning in the vicinity

of the "T" bar. One urchin lost its tag in this manner after 9 months and appeared to be recovering when collected for study.

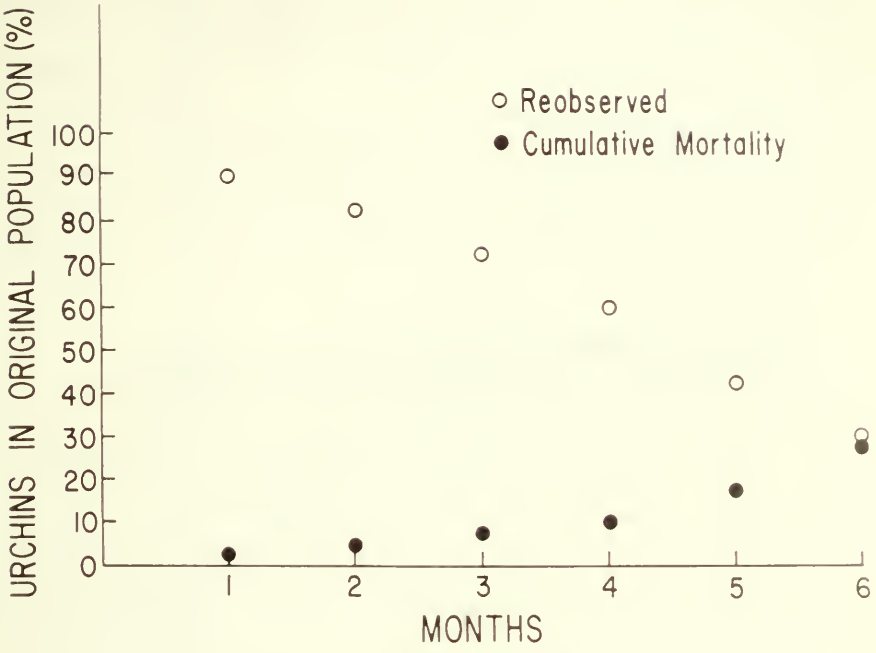

FIGURE 3. Percentage survival and mortality of 40 sea urchins tagged January 1976

Higher recovery figures may be obtained if fish predation on tagged sea urchins can be reduced. Several tags have been found lying free of any sea urchin's test with tooth marks on the identification discs and with bent "T" bars. We attribute these losses to sheephead, *Pimelometopon pulchrum,* biting and pulling the tags from the sea urchin's test. Plastic fluorescent pink streamers were attached to some tags to aid in relocation, but we observed that these were soon shredded and lost to garibaldi, *Hypsypops rubicunda.* To eliminate this fish-inflicted mortality, shorter tags with green identification discs are being evaluated. The short tag shaft should keep the identification discs lower among the spines and protect it from sheephead and other curious fishes.

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Mark Olsson and Gerald Newton, University of California, San Diego, La Jolla, CA 92093. *Accepted for publication July 1977.*

FOOD HABITS OF SQUIRRELFISH, *ADIORYX SUBORBITALIS*, IN THE GULF OF CALIFORNIA

The squirrelfish, *Adioryx suborbitalis* (Beryciformes: Holocentridae), which ranges from the central Gulf of California to Ecuador and the Galapagos Islands (Thomson and McKibbin 1976), is reported to be a nocturnal feeder that forages mainly on small crustaceans (Hobson 1968; Thomson and McKibbin 1976). In an effort to characterize more fully the food habits of this species, we speared 12 specimens in the Gulf of California along the coast of Baja California Sur, between Loreto and Cabo Pulmo, during July and August 1976. The fish ranged from 160 to 245 mm (6.3 to 9.7 inches) total length (TL). We did not measure food volumes, but counted only the numbers of recognizable, individual prey items in the stomachs. All fish were taken shortly after sunrise (0600 to 0800 hr), when their stomachs were full and digestion had not yet rendered the contents unrecognizable. We found these fish congregated in groups of 10 to 40 in crevices under rocks during early daylight hours.

Crabs, primarily brachyurans, were the dominant food type in all but the smallest (160 mm TL) individual which had eaten four small sergeant majors, *Abudefduf troschelii*, and two shrimps (Table 1). Other food items were amphipods, shrimps, gastropod molluscs, isopods, and fish. Two stomachs contained fish bones and one contained a 6-mm long bivalve mollusc shell and one sea urchin spine which could have been picked up with the crabs. Altogether, crustaceans comprised 93.7% of the total stomach contents, confirming Hobson's (1968) general observation. Although these fish sometimes were observed to make forays from their rock lairs during daylight hours, but seldom in direct sunlight, no feeding was observed during the day, thus confirming their nocturnal foraging behavior. The presence of fish and gastropods in some stomachs, as possibly the bivalve mollusc and sea urchin sprine, indicates an opportunistic component in food selection of squirrelfish. The temporal pattern of nocturnal feeding and diurnal occupation of rock crevices is diametrically opposed to the habits of the diurnal substrate-feeding angelfishes *Pomacanthus zonipectus* and *Holacanthus passer* (Reynolds 1977; Reynolds and Reynolds 1977) which are sumpatric with *A. suborbitalis*. Competition among these species is an example of temporal resource partitioning. Competition is for space rather than for food because angelfishes feed largely on sponges.

TABLE 1. Numbers and Types of Food Items Found in Stomachs of 12 *Adioryx suborbitalis* from the Southern Gulf of California

Total length of fish (mm)	*Crabs (mostly Brachyura)*	*Amphipods*	*Shrimps (Natantia)*	*Isopods*	*Gastropods*	*Fish*	*Miscellaneous items (not included in %)*
160	0	0	2	0	0	4	
172	16	0	0	2	1	0	
187	17	0	0	2	0	0	fish bones
190	88	58	0	1	1	3	
197	49	0	0	0	3	0	1 (6-mm) bivalve
200	7	0	4	0	1	1	
200	13	0	0	0	3	0	1 urchin spine
215	18	0	5	3	3	0	
225	7	0	0	1	1	2	fish bone
233	15	0	0	1	0	0	
235	30	0	6	2	3	0	
245	56	0	2	1	1	0	
Totals	316	58	19	13	17	10	
No. fish found in	11	1	5	8	9	4	

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James K. Matthew and William W. Reynolds, Department of Biology, The Pennsylvania State University, P.O. Box 1830, Wilkes-Barre, Pennsylvania 18708.
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